Etowah River Basin Stressors Analysis

Construction site on Westbrook Creek, Cobb County; an example of a stressor to imperiled fish species in the Etowah. Photo by Jesslyn Storey.

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I. Introduction

The Etowah River Basin (Figure 1-1) is a highly biodiverse and highly imperiled aquatic ecosystem located just north of Atlanta, Georgia. Its precarious status and diversity of fauna have made it an object of scientific research for the last several decades. In recent years it has also become the focus of conservation and management efforts designed to protect aquatic habitat and prevent species extinctions. The purpose of this report is to help guide protection efforts through (a) a review of the major threats or *stressors* to the sensitive aquatic species in the basin; (b) a discussion of the tools that have been developed to manage these threats; and (c) a presentation of potential stream bank mitigation sites in the Upper Etowah.

The Etowah River Basin and Its Fauna

The Etowah River is a major headwater tributary of the Coosa River system of the Mobile River drainage. Lying entirely within Georgia at the foothills of the Southern Appalachians, it originates in the Blue Ridge physiographic province but also drains Piedmont and Valley & Ridge provinces. Because the mainstem of the Coosa is impounded by reservoirs along most of its length, many species that were originally more widespread are now found only in the headwater tributaries, such as the Etowah. The Etowah itself is split by the 4800-ha Lake Allatoona, below which many mainstem fish species are thought to be extirpated. The Etowah River Basin supports three federally protected fish species, five state protected fish species, several fish species likely to become candidates, and possibly as many as five species of federally protected mussels (see Table 1). The amber darter (*Percina antesella*) and the Etowah darter (*Etheostoma etowahae*) are listed as federally endangered, while the Cherokee darter (*Etheostoma scotti*) is listed as federally threatened; both the Etowah and Cherokee darters are endemic to the Etowah. The frecklebelly madtom (*Noturus munitus*), freckled darter (*Percina lenticula*), holiday darter (*Etheostoma brevirostrum*) and bridled darter (*Percina* sp. cf. *macrocephala*) are state-listed in Georgia. In addition, the holiday darters of the Etowah are believed to be two separate species, each endemic to a subwatershed of the Etowah and both likely to become candidates for federal listing once described; similarly, the frecklebelly madtom of the Etowah is thought to belong to an undescribed species endemic to the Upper Coosa. An undescribed species of speckled chub (*Macrhybopsis* sp. cf. *aestivalis*) is also believed to be endemic to the Coosa; some of its best remaining habitat is in the Etowah. Federally listed mussel species formerly known from the Etowah and likely extirpated include the upland combshell (*Epioblasma metastriata*), southern clubshell *(Pleurobema decisum*), ovate clubshell (*Pleurobema perovatum*), triangular kidneyshell (*Ptychobranchus greeni*), and Alabama moccasinshell (*Medionidus acutissimus*). A species of insect called the Etowah caddisfly (*Brachycentrus etowahensis)* is known only from the Etowah and the Hiawassee rivers.

Many of the imperiled fish of the Etowah are riverine species, occurring only in the mainstem and the lower reaches of large tributaries. The Cherokee darter is a small-stream species, while the Etowah darter, bridled darter and the holiday darter occupy medium-sized streams to small rivers. Figures 1-1, 1-2, and 1-3 show the known distribution of these imperiled fish species. Figure 1-4 shows the total known distribution of all imperiled fish species, along with unsurveyed watershed that we believe are likely to support populations of imperiled species.

All of the imperiled mussel species listed in Table 1-1 are believed to be extirpated, but are included here because of the possibility of reintroduction. As many as 50 species of mussels may have lived in the Etowah (Burkhead *et al.* 1997), but only a few small populations of tolerant species have been collected in recent years (Bud Freeman, unpublished data; Chris Skelton, unpublished data). It is unknown why virtually all mussels have been extirpated from the system while a majority of the fish species has persisted.

This report will focus on the fish species since they are extant in the basin. Special attention will be given to the Cherokee darter, which inhabits small streams across the portion of the basin that lies within the Piedmont physiographic province. It is easier to correlate human activities with the presence or absence of small stream fishes. In contrast, riverine species are impacted by activities across numerous tributary watersheds, making it more difficult to determine the origin of stressors. Another reason for focusing on the Cherokee darter is that its range coincides with the most intense development activity in the basin.

The Nature Conservancy's Site Conservation Plan

The imperiled diversity of the Etowah has attracted the attention of The Nature Conservancy (TNC). In December 2000, TNC held an "Expert Workshop" in Athens, Georgia to identify focal targets for preservation in the Upper Etowah (the watershed above Lake Allatoona). In the jargon of TNC, a "target" is a single species, or a set of species with similar habitat requirements, that is the focus of protection efforts. Two of the authors of this paper (Freeman and Wenger) participated in the workshop, along with other scientists from the University of Georgia and the Georgia Natural Heritage Program. The conservation targets identified by the group included:

- (a) Small stream fish assemblage
- (b) Etowah mainstem fish assemblage
- (c) Mussels
- (d) Floodplains/swamp systems
- (e) Xeric ridges and bluffs

Threats to the small stream assemblage were identified as sedimentation, pollutants/toxins, fragmentation, hydrologic alteration, habitat alteration, and exotic species. Threats to the mainstem assemblage were essentially the same, although exotic species were not listed (this partly reflects the fact that exotic species do not presently appear to be a major problem in the Etowah, but it also may have been an oversight). Workshop attendees agreed that urbanization was the principle source of the major threats to the imperiled aquatic fauna. Due to lack of time and information, threats were not listed for the other targets.

Strategies for managing the threats to the fishes included:

- Refocusing Clean Water Act Section 319 grant funds from agricultural Best Management Practices (BMPs) to urbanization management
- Educating stakeholders
- Enforcing existing BMPs
- Acquisition and protection of land
- Policies for cluster development (conservation subdivisions) and greenspace preservation
- Creation of a basin-wide watershed development plan approved by all counties.

In July of 2001, TNC held a Conservation Strategies Meeting for the Upper Etowah. This meeting involved a wider range of participants, including representatives of U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, The Georgia Conservancy, the Upper Etowah

River Alliance and local governments, in addition to representatives of TNC and UGA. At this two-day session, participants drafted a set of priority strategies for reducing the impacts of stressors on selected conservation targets. The strategies included:

1. Promote the development of a Regional Water Supply Plan. This would be a program to determine water supply needs and develop ways to meet them, as an alternative to simply constructing reservoirs.
2. Develop a watershed-scale greenspace plan to facilitate the protection of land and water resources on a regional scale.
3. Improve enforcement of erosion and sedimentation control laws.
4. Create alternative development scenarios for counties in the Upper Etowah basin, to facilitate planning practices that are more protective of target resources.
5. Work towards the goal of permanently protecting the Dawson Forest and other critical undeveloped portions in the Upper Etowah.

In addition, the group identified two secondary strategies to support the major strategies listed above. These were called “leverage strategies.”

1. Develop a “marketing plan” for the Etowah River—a high-quality public education program that promotes the value of biodiversity and increases public support for good resource protection policies.
2. Identify the sources of nutrient contamination in the Etowah through a study conducted by the University of Georgia, which would provide guidance for managing the sources of this stressor.

This report is intended to complement the TNC site conservation planning process by providing a more in-depth analysis of the threats to the aquatic target species. In the last chapter of this report we will discuss how the information in this report can be incorporated into the TNC program and other ongoing efforts to protect the imperiled species of the Etowah basin.

Table 1-1. Imperiled Aquatic Species of the Etowah River Basin.

Scientific Name	Common Name	Status
Percina antesella	amber darter	Fed. Endangered
Etheostoma etowahae	Etowah darter	Fed. Endangered
Etheostoma scotti	Cherokee darter	Fed. Threatened
Noturus sp. cf. *munitus*	frecklebelly madtom	GA Threatened
Etheostoma sp. cf. *brevirostrum* A	holiday darter	GA Threatened
Etheostoma sp. cf. *brevirostrum* B	holiday darter	GA Threatened
Percina sp. cf. *macrocephala*	bridled darter	GA Rare
Percina lenticula	freckled darter	GA Endangered
Macrhybopsis sp. cf. *aestivalis*	speckled chub	--
Epioblasma metastriata	upland combshell	Fed. Endangered
Pleurobema decisum	southern clubshell	Fed. Endangered
Pleurobema perovatum	ovate clubshell	Fed. Endangered
Ptychobranchus greeni	triangular kidneyshell	Fed. Endangered
Medionidus acutissimus	Alabama moccasinshell	Fed. Threatened
Brachycentrus etowahensis	Etowah caddisfly	--

Figure 1-1. Distribution of Holiday Darters and Cherokee Darters in the Etowah Basin.

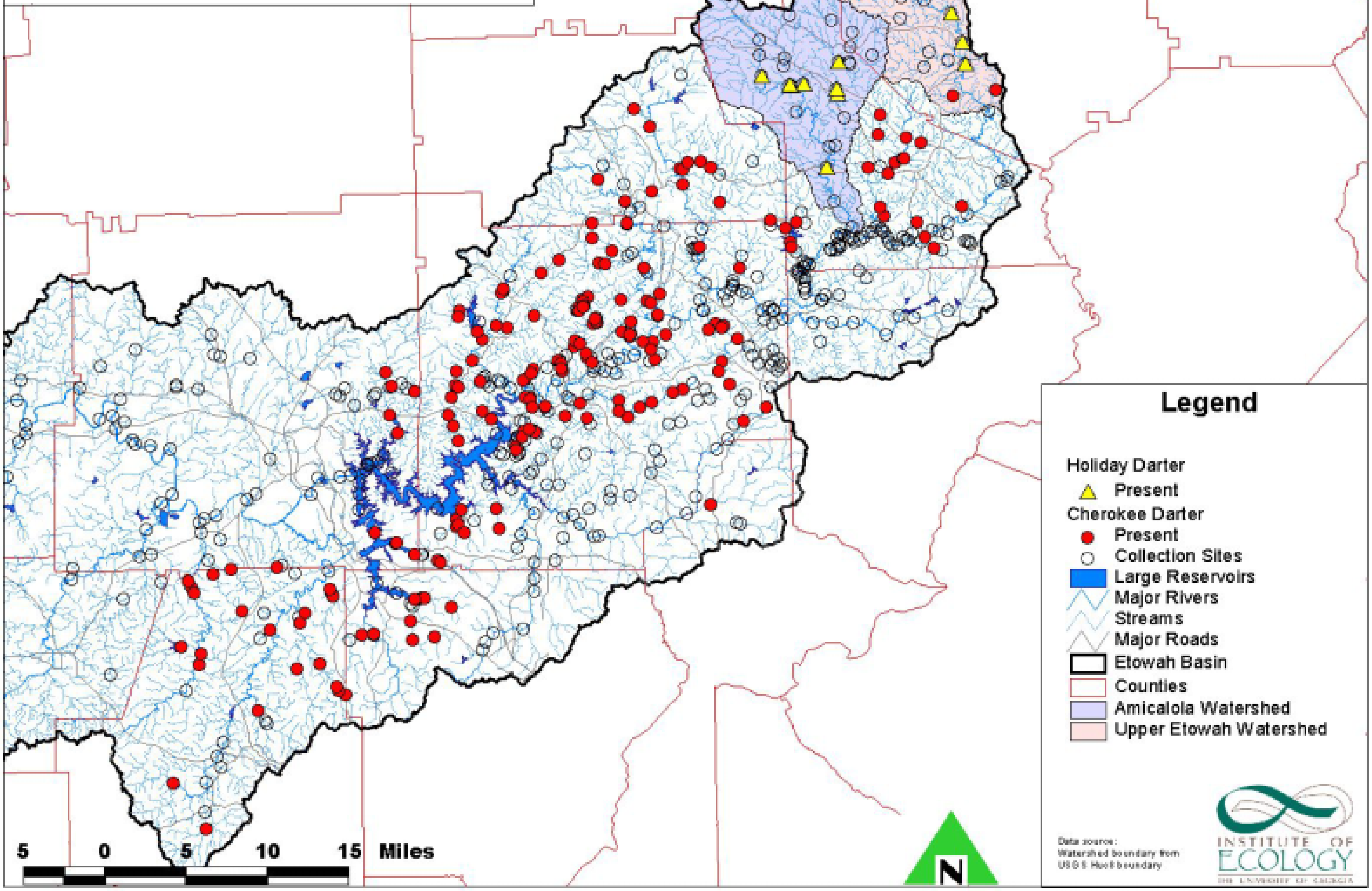
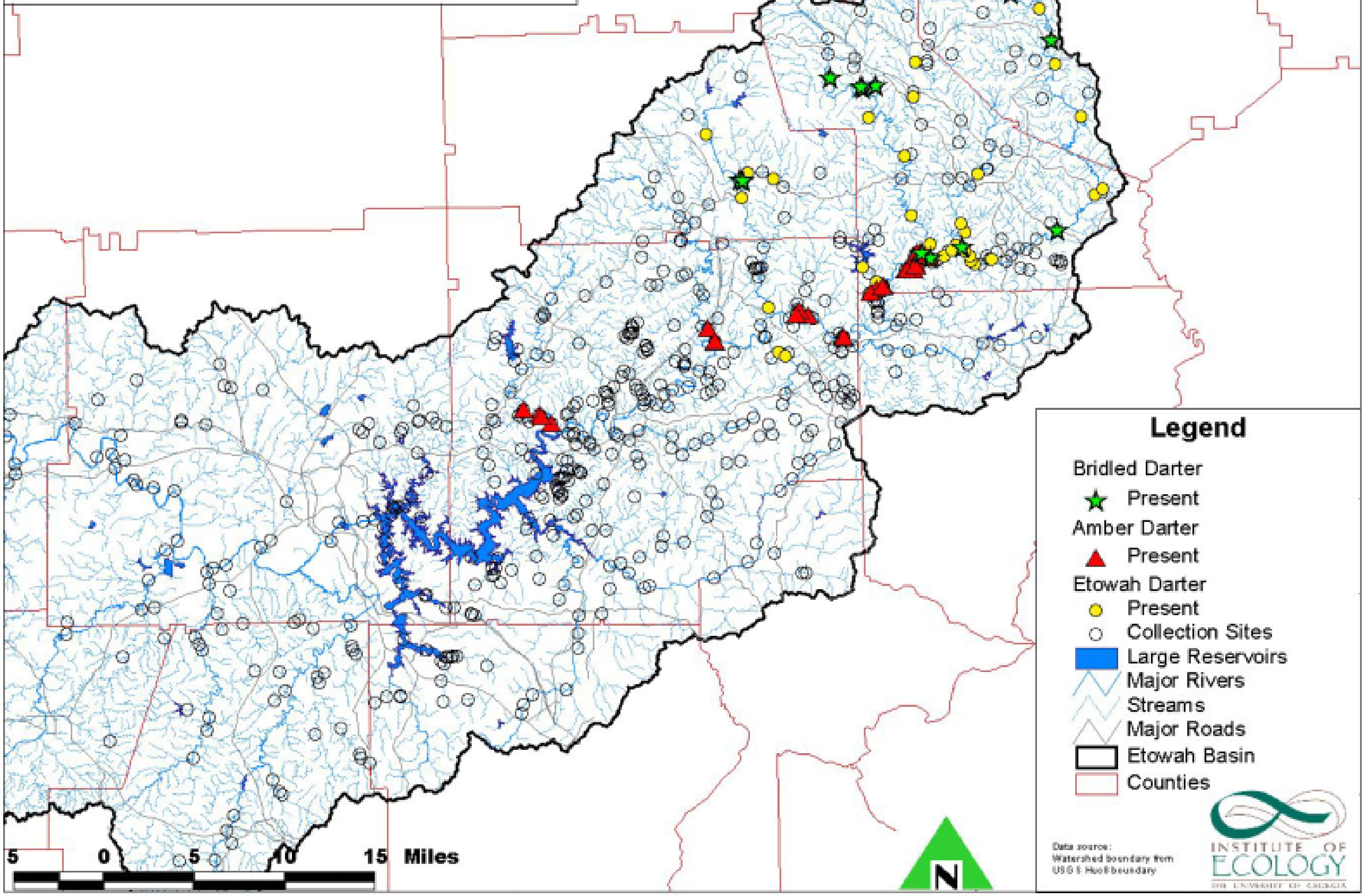


Figure 1-2. Distribution of the Etowah, Amber, and Bridled Darter in the Etowah Basin.



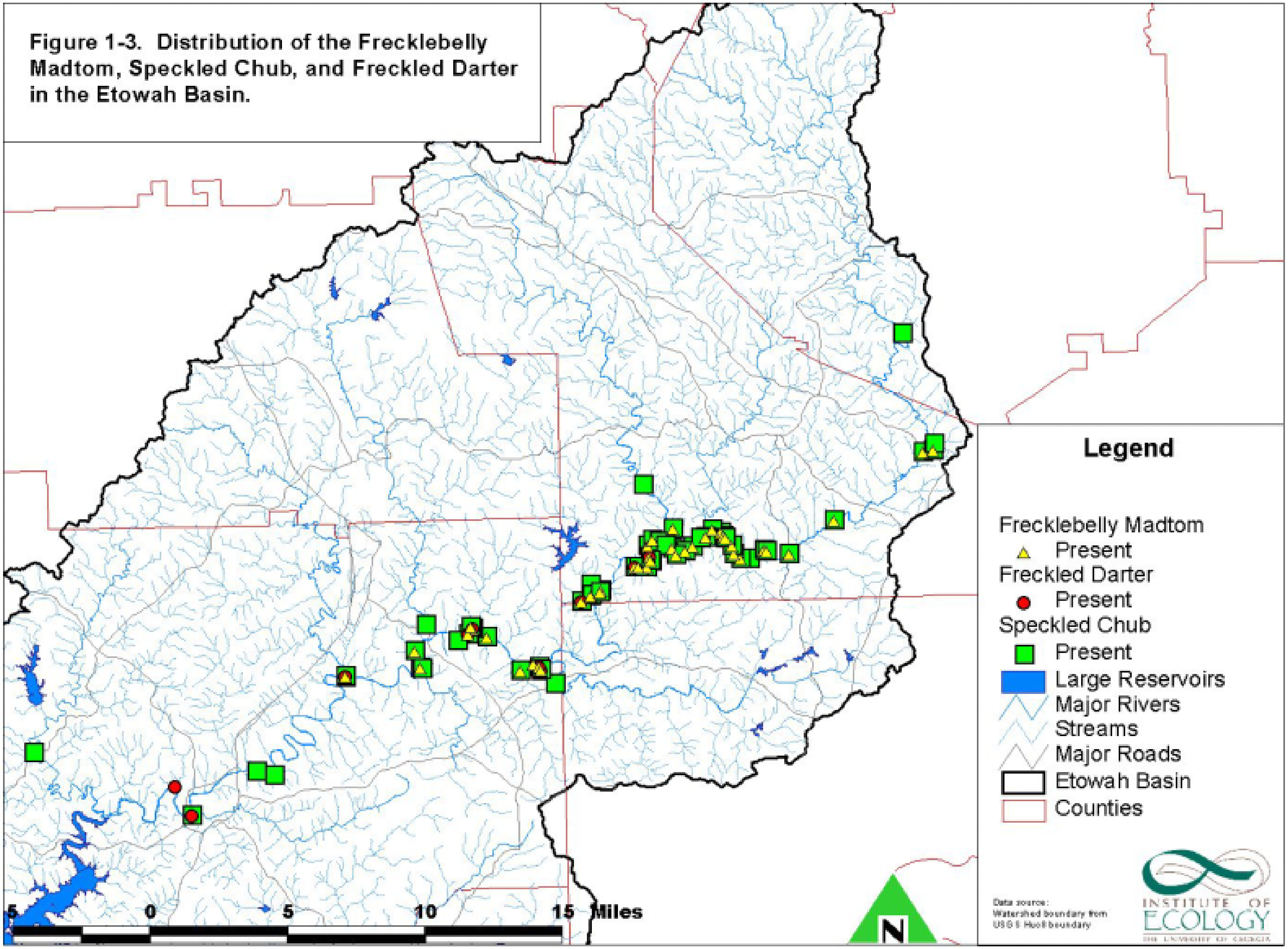
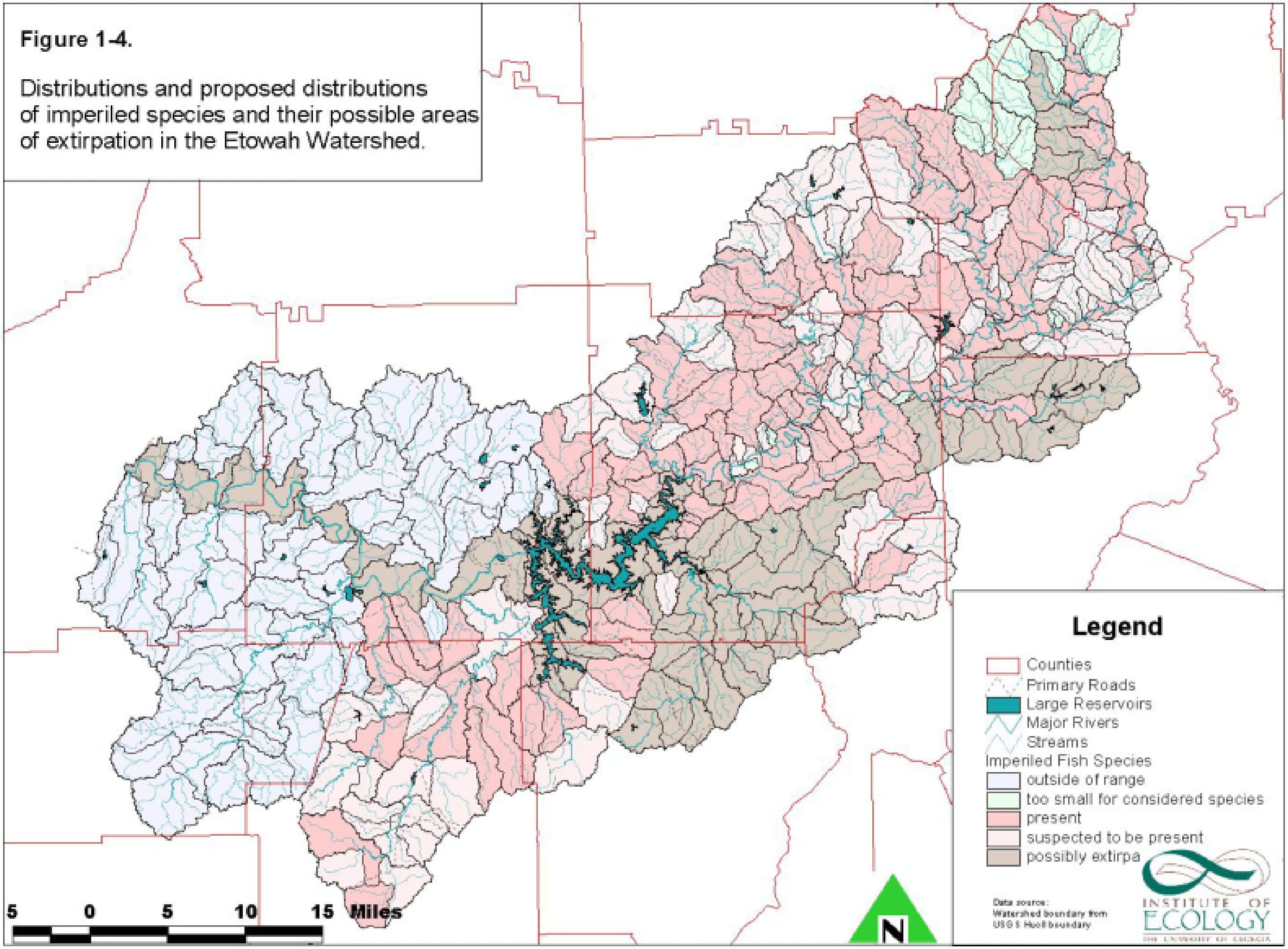


Figure 1-3. Distribution of the Frecklebelly Madtom, Speckled Chub, and Freckled Darter in the Etowah Basin.

Figure 1-4.

Distributions and proposed distributions of imperiled species and their possible areas of extirpation in the Etowah Watershed.



II. The Stressors

Urbanization in the Etowah

The consensus at the TNC experts workshop was that urbanization represents the greatest threat to the survival of both small-stream and mainstem aquatic species. We believe that conclusion is correct, for two reasons:

- Generally, streams draining urban watersheds tend to be more degraded than those draining agricultural or forested watersheds (Crawford and Lenat 1989, Wang *et al.* 2000). In the Etowah, Cherokee darters are found in streams with significant agricultural uses, but appear to be absent from most heavily urbanized streams (pers. obs.). Wang *et al.* (2001) observed that it is possible to mitigate the impact of agriculture with the use of proper best management practices, but once urbanization reaches a certain threshold severe aquatic degradation is inevitable. Therefore, stressors associated with urbanization have greater potential impact than those associated with agriculture and forestry land uses.
- Urban land cover has steadily increased in the Etowah basin over the last 20 years. This trend is expected to continue, especially in the southern portion of the basin (Atlanta Regional Commission 2001; Department of Community Affairs 2001). Major projects such as the proposed Northern Arc—a highway that would bisect the Etowah basin—will undoubtedly attract additional growth. Agriculture and forestry land uses are declining as urbanization increases. The current land cover in the Etowah Basin is shown in Figure 2-1.

Stressors to Sensitive Etowah Fish Species: A Conceptual Model

Fishes are impacted by urbanization and other land uses in many ways. In fact, the mechanisms that cause the extirpation of sensitive fish in a watershed are often unknown, although potential culprits can usually be identified. Figure 2-2 shows a conceptual model of the ways in which we believe factors impact sensitive fish species in the Etowah. This model is intended to describe conditions in the Etowah, where fishes are impacted by a range of land uses, dominated by the threat of urbanization. The left side of the diagram indicates the five classes of requirements for the long-term persistence of sensitive fish:

- Healthy Water. Water of the appropriate temperature, with adequate oxygen, low turbidity, and without excessive chemical pollutants.
- Physical Habitat. This includes spawning habitat, refugia from predators, and foraging habitat. Many imperiled species in the Etowah are obligate benthic species (Burkhead et al. 1997) that require shallow riffles of clean cobble or gravel as habitat.
- Food. Many imperiled species consume benthic invertebrates, which also depend on shallow riffles.
- Few Competitors and Predators. This could be also be stated as a natural density of competitors and predators. Invasive species introductions, predators from reservoirs and altered food webs can cause an imbalance in the naturally evolved system of competition and predation.
- Connections to Other Populations. Movement barriers, such as dams and perched culverts, can disconnect populations of a species. This isolation can prevent recolonization after an extirpation event, and lead to genetic bottlenecks in small populations.

A range of impacts from multiple sources can impair these requirements for sensitive fishes. Note that background factors—such as geology and slope—are omitted from this model, although they may have important effects at various levels. For example, the original habitat quality depends on the underlying geology, and the sensitivity of the habitat to sedimentation depends on the local (longitudinal) slope of the channel.

This type of conceptual model allows us to put the complex web of stressors into an understandable framework. In this chapter, we will present the threats shown in the third column of Figure 2-2 as the major stressors of the Etowah, along with sources of these stressors. In the next chapter we discuss ways of managing these stressors.

The Stressors

High Water Temperature
Every aquatic organism is adapted to a certain range of temperatures. Naturally, species vary in their temperature preferences and their sensitivity to deviations. Trout are a well-known example of fish that cannot tolerate water above a certain temperature; the presence or absence of trout can often be explained on the basis of water temperature (e.g., Barton *et al.* 1985). Preliminary data from an ongoing study of trout streams in North Georgia have confirmed this result (Judy Meyer, pers. com., Dec. 2001). Mussels are known to be sensitive to temperature as well (Morris and Corkum 1996).

For small to medium sized streams, shading from riparian forests is critical in maintaining proper water temperature (Barton *et al.* 1985, Collier *et al.* 1995). Temperature increases can also be traced to stormwater runoff from impervious surfaces that tend to be warmer than runoff from vegetation and soil. Reservoirs also alter downstream water temperature; whether warmer or cooler depends on whether the dam releases water from the top (epilimnetic) or bottom (hypolimnetic). Most small dams in the Etowah are epilimnetic, potentially causing increased water temperature downstream (pers. obs.). Many large hydroelectric dams are hypolimnetic, providing cool-water conditions that allow such unnatural anomalies as the trout fishery in the Chattahoochee below Lake Lanier. Finally, point source discharges of pollution can contribute to elevated water temperatures.

Chemical Pollutants.
There is a long list of inorganic and organic chemical pollutants that can be found in streams and rivers. In addition to nutrients, which are considered separately, such pollutants can include heavy metals, pesticides, chlorine, chlorination byproducts, hydrocarbons, polyaromatic hydrocarbons, pharmaceuticals, hormones and detergents. The effects of many potential pollutants have not been tested on fish, and their impacts are poorly known (Kolpin et al. 2002, USGS 2001a). Further, it is expensive to test for many constituents, so unless it is possible to narrow the range of culprits, full analysis is impractical. For these reasons, we know little about the role chemical and organic pollutants play in the extirpation of sensitive fish species. Some recent studies have found that sensitive fish species are absent from some urban streams, despite the presence of adequate habitat, which suggests the possibility that chemical pollutants are to blame (Wang *et al.* 2000). Pollutants may be most damaging when fish are under stress from other sources and during winter months, when feeding declines (Lemly 1996). The sources of

chemical pollutants in the Etowah include point sources, stormwater runoff from impervious surfaces, use of pesticides on agricultural lands, lawns and golf courses, and accidental spills.

Although point source discharges are regulated, discharge permits often only specify limits of one or two compounds out of hundreds or thousands that may be present. Municipal wastewater treatment plants, for example, may be permitted with discharge limits only on biological oxygen demand and suspended solids. Although the activated sludge process of wastewater treatment plants can remove other pollutants as well, plants may still discharge a range of chemicals at concentrations high enough to cause potential environmental problems (Kosmala et al. 1998).

Stormwater runoff from impervious surfaces can contain an array of metals, hydrocarbons, nutrients and other chemicals, as well as suspended solids. Current stormwater regulations in most jurisdictions do not require water quality treatment, although some pollutant removal may occur in wet detention ponds.

Pesticides are ubiquitous in aquatic systems. A study by the National Water Quality Assessment (NAWQA) Program found pesticides in nearly every stream and river sampled (USGS 2001a). About a billion pounds of pesticides are applied each year in the United States, with about 70-80% on agricultural lands (USGS 2001a), although rates of application are actually higher in urban areas (USGS 2001b). Guidelines for protecting aquatic life exist for only 18 of the 88 pesticides for which the NAWQA program tests (USGS 2001b).

Accidental spills are sources of pollutants that are difficult to regulate, though potentially very damaging. For example, the “Sandoz Incident” in Basle, Switzerland, involved the deaths of half a million fish when 30 metric tons of agricultural chemicals were accidentally washed into the Rhine River (Dowson et al 1996). In the Etowah, a large fish kill resulted when a truck carrying the pesticide Dursban overturned into Puckett Creek in 1998.

High Turbidity

Streams in the Etowah, like most in Georgia, become highly turbid during storm flows, although most run clear to moderately clear during low flows (pers. obs.). Turbidity is closely correlated with suspended sediment, although turbidity may also result from organic sources. Many fish are visual feeders, so high turbidity prevents them from foraging effectively (Waters 1995). In addition, high concentrations of suspended sediment may cause stress and direct mortality. Fish leave areas of high suspended sediment concentrations (Waters 1995). We believe the most significant source of high turbidity in the Etowah is sedimentation, described below.

Sedimentation

Sedimentation is associated with high turbidity, but its most significant impacts on aquatic species relate to its effects on physical habitat. In fact, Waters (1995) notes that fine sediment “overwhelmingly constitutes one of the major environmental factors—perhaps the principle factor—in the degradation of stream fisheries.” Sediment can bury riffles in a layer of sand, silt and clay that can be several inches to several feet deep.

Sedimentation is associated with both urban and rural land uses and can come from a number of sources. The most visible source of sedimentation in urban and suburban areas is from construction sites. Although effective Best Management Practices (BMPs) for erosion and sedimentation control exist, they are frequently not used, are misused or are not maintained (Brown and Caraco 1997). Terrestrial erosion may decrease as a watershed becomes fully developed because much of the soil is covered under a layer of asphalt and concrete (Arnold *et al.* 1982). Despite this, many urban streams still suffer from sedimentation that exceeds what is expected from construction sites (Pizzuto *et al.* 2000). In some streams the main source of sedimentation appears to be channel erosion from high storm flows (see *Altered Flows*, below).

Lack of Woody Debris
Large woody debris is an important component of aquatic habitat, creating pools, refugia for fish, and habitat for macroinvertebrates. Certain species rely heavily on the presence of debris. In the Northwest, many researchers have found that the amount of woody debris in a stream is the primary factor in determining the health of salmonid habitat (Finkenbine *et al.* 2000, May *et al.* 1996). In sandy-bottom rivers of the Coastal Plain in the southeast, debris may be the only source of habitat diversity. However, most of the imperiled species of the Etowah basin probably rely more on other habitat components, such as gravel-cobble riffles.

A lack of woody debris can be caused by an absence of riparian forests, which are usually the chief debris source, and by very high storm flows, which can wash debris away. Degraded urban streams could be greatly improved by adding woody debris, anchoring it if necessary (Finkenbine *et al.* 2000; Gustav *et al.* 1994). While there may be substantial merit to this approach in some river systems, we do not believe it should be the cornerstone of a restoration program for the Etowah and its tributaries. Instead, we recommend protecting and restoring riparian forests, combined with controlling stormwater flows.

Altered Flows
Stream habitat is created and maintained by hydraulic forces. The size of the channel is determined by storm discharges, especially the “bankfull” (channel-filling) discharge which occurs approximately once every one to two years (Dunne and Leopold 1978). Stormflows also exert considerable control over the size and distribution of sediment particles. Altered flows frequently result in degraded fish habitat. Urbanization poses the greatest threat to flows in small streams in the Etowah, while the operation of Lake Allatoona has greatly altered flows in the mainstem of the river.

Urbanization leads to increased stream “flashiness” (storm flows are higher and more frequent, while base flows are lower) (Ferguson 1998, Dunne and Leopold 1978). The storm discharge of urban streams can be twice that of rural streams draining watersheds of similar size (Rose and Peters 2001, Pizzuto 2000). The high flows scour channels, causing erosion that can be the dominant source of sedimentation in urban streams (Trimble 1997). In an urbanizing watershed, the frequency of channel-forming events can be ten times that of the pre-development conditions (Booth and Jackson 1997). Over time the channel will widen to reach a point of equilibrium (i.e., the channel is wide enough that the velocity drops to a point where it no longer causes scour). This can take decades, however (Finkenbine *et al.* 2000). Even at equilibrium, the base flow may be out of balance with the size of the channel—i.e., the channel is that of a large stream, but the flow is that of a small stream—so that insufficient habitat is available. We suspect the extent of this problem is quite significant, although it has not been adequately studied.

The degree of urban stream flow alteration depends greatly on the amount of impervious surface in the watershed. Significant impacts appear at relatively low levels. Many researchers have identified 10-12% impervious surface coverage as a threshold above which physical degradation becomes apparent (e.g. Schueler 1994, Arnold and Gibbons 1996, May *et al.* 1997, Wang *et al.* 2000).

Flows are also altered by forestry activities. When a large number of trees are removed from a watershed, the flow in the stream will increase due to the decrease in evapotranspiration (Allan 1995). As a forest regenerates, the stream should gradually return to its original flow. Therefore, the impacts of forestry tend to be less permanent than those of urbanization.

Finally, flows may be severely altered by reservoirs. The Etowah River mainstem is impounded by Lake Allatoona, a 4800 ha multiple-use reservoir constructed by the U.S. Army Corps of Engineers in 1950. Because the reservoir is used for power generation, the discharge is highly regulated and shows dramatic fluctuations typical of hydroelectric dams. The imperiled species found in the mainstem of the Upper Etowah—the amber darter, the frecklebelly madtom, the freckled darter, the bridled darter and the speckled chub –are all absent below the reservoir. It is not known whether the dam has caused the extirpation of these species, since virtually no pre-impoundment surveys were conducted in the Lower Etowah. Nevertheless, it is likely that at least some of these species once were present in the Lower Etowah and now are absent due to flow regulation, water quality impacts and sedimentation associated with the operation of Allatoona Dam. The fish assemblage immediately below the dam is depauperate, although additional species appear with increasing distance downstream from the dam (Burkhead et al. 1997). While this is not conclusive, it suggests that many imperiled mainstem species could thrive in the Lower Etowah if the river were permitted to flow in a more natural manner.

Excess Nutrients
Nutrient pollution has long been implicated in the degradation of lakes and ponds. Excess nutrients, especially phosphorus (in freshwater systems), can cause algal blooms that subsequently die off and deplete oxygen, leading to fish kills. As a rule streams and rivers do not suffer problems as severe as lakes, but there are exceptions. Algal blooms in the Conasauga River in fall of 2000 covered high-quality habitat in a filamentous slime (Freeman and Wenger 2001). The bloom occurred concurrently with low flows in the mainstem during one of the worst droughts on record. In 2001 algae were less evident, possibly due to the higher flows. Our working hypothesis is that the Conasauga regularly suffers from nutrient enrichment, but this only leads to algal blooms when flows are low, when more sunlight can penetrate to the benthos and no storm flows occur to flush out the algae. We have not observed such algal blooms in the Etowah, but they nevertheless represent a potential threat to the mainstem and to low-gradient tributaries.

Ammonia and nitrate are toxic at high concentrations. Ammonia and low dissolved oxygen have been found to interact to cause greater fish mortality than either factor operating independently

(Magaud et al. 1996). This is especially problematic considering that elevated levels of ammonia and hypoxia are likely to occur simultaneously in a eutrophied river.

Agricultural sources of nutrients in the Etowah include fertilizer applied to row crops, chicken litter applied to pastures as a method of disposal, and cattle that have direct access to streams and rivers. While row crop agriculture is not widely practiced in the basin, it is still significant in some subwatersheds, and the suburban equivalents of row crop agriculture, sod farms and nurseries, are present as well. Cattle farms are not uncommon and we have observed cattle standing in rivers and streams. Chicken production is widespread. It is common practice to dispose of chicken litter by spreading it on pastures, sometimes in excess of the rate that can be bound by soil or taken up by vegetation. When it rains shortly after litter application, or when phosphorus accumulates to high levels in the soil, the likelihood that nutrients will be transmitted to surface waters is increased (Chapman 1996).

In urban and suburban areas, sources of nutrients include leaking septic systems, leaking sewer lines, fertilizer applied to lawns and golf courses, runoff from impervious surfaces (where waste from pets and wildlife may be the source), and wastewater treatment plant discharges. The relative contribution of each of these sources is poorly known.

Altered Food Webs

The food web of aquatic systems may shift dramatically when nutrient inputs or top predators change. In the Etowah system, we believe the chief threats are likely to be increased nutrients (discussed above) or loss of riparian cover, which can shift a stream from heterotrophy to autotrophy. Both changes can lead to algal blooms, which can alter the supply and availability of benthic invertebrates that are a food source for many imperiled species. Blooms can also lead to an overabundance of fish such as *Campostoma*, which scrape algae from rocks.

Excess Competitors & Excess Predators

Competition and predation are pressures that affect all fish. The extant fish species have adapted to endure a certain level of both of these stresses, but it is possible for human activities to dramatically increase pressures of competition and predation. Invasive species constitute one potential source. Reservoirs constitute a second source, since they may serve as breeding habitat or stocking areas for lentic species that may range upstream into lotic habitat to feed (often, the two sources are correlated as invasives may be stocked within reservoirs). In addition, altered food webs can lead to an unnatural abundance of certain species, whose presence may place undue pressures on imperiled species.

Invasive Species Introductions

There are 13 species (or hybrids) of non-indigenous species known to occur in the Etowah basin (Burkhead *et al.* 1997). These species are listed in Table 2-1 and known occurences are mapped in Figures 2-4 through 2-7. Our database records are limited for many of these species, so these maps should not be considered definitive. In fact, no records of brook trout, yellow bass and white bass-striped bass hybrids appear in our fish collection database for the Etowah, so these are not mapped. However, white bass, striped bass, and white/striped hybrids all are common in Allatoona Reservoir and frequently occur in the Upper Etowah mainstem as well.

The three species we consider most likely to cause a significant impact on imperiled fish in the Etowah system are the grass carp, common carp and red shiner (Figure 2-7). Both carp species have potential to modify local habitats by consuming and reducing aquatic macrophytes. The adaptability and tolerance of the red shiner makes it an effective invasive with the ability to outcompete some native *Cyprinella* species (Etnier and Starnes 1993). The redbreast sunfish, although widely distributed, has long been naturalized in the Etowah system, as well as many other watersheds outside its original range. We do not believe it is a major competitor of any of the imperiled species, nor do we think it represents a significant risk as a predator. Other invasive species are limited by temperature and habitat requirements to certain portions of the watershed and do not appear to have the potential for major impacts.

Asiatic clam (*Corbicula fluminea*) is a widely distributed invasive shellfish that is found throughout the Etowah basin. Its success may be due in part to the absence of native mussels, which appear to have been extirpated prior to the arrival of the Asiatic clam. The organism may pose a threat to the reintroduction of mussel species.

Movement Barriers

Long-term survival of a fish population is greatly enhanced by connections to other populations of the same species. Although there are examples of species persisting in small, isolated locations (such as the Devil's Hole pupfish), these are likely to be anomalies, since such a species can easily be eliminated by a localized event. If a species is composed of many connected population, the elimination of any one group (say, due to a chemical spill) will not jeopardize the species since other individuals can recolonize the habitat later. Population interconnections also impart genetic variability to a population. Isolated populations may suffer from inbreeding and loss of genetic variation that reduce their evolutionary flexibility in responding to other stressors (Meffe and Caroll 1997).

Two types of movement barriers are ubiquitous in the Etowah: dams and road crossings. There are over three thousand dams in the Etowah, based on existing GIS data for water bodies (polygonal hydrography digitized from USGS topographic maps), which provide a reasonable estimate of the number of impoundments in the Piedmont, since there are very few natural lentic water bodies. While dams are not always impenetrable barriers, the reservoirs associated with them are extremely hostile environments for many lotic species. The combination of dam and reservoir constitutes a formidable obstacle for imperiled fish. A road crossing that employs a culvert can also be a barrier, either due to high flows through the culvert or to a drop at the downstream end. Bottomless culverts, embedded culverts and freespan bridges are much less likely to serve as barriers than traditional pipe culverts (Warren and Pardew 1998).

Ranking Stressors and Their Sources

It is difficult to identify which of the stressors discussed in this chapter represent the greatest threats to the imperiled species of the Etowah. Locally, each of the stressors can be highly problematic. It is tempting to allow the list to stand without any form of ranking, but this not terribly helpful to management efforts. Therefore, we have attempted to classify stressors as "major" or "moderate," based on (1) their ubiquity; (2) their severity; and (3) the threat they pose to imperiled fish species. This ranking reflects a good deal of subjectivity and we recognize that many others will not agree with it. Further research may provide information that will cause us to reevaluate this listing. In addition, as new management efforts are introduced, some stressors may decline in importance.

Major Stressors
Chemical and Organic Pollutants
Sedimentation
Altered Flows
Movement Barriers

Moderate Stressors
High Water Temperature
Lack of Woody Debris
Excess Nutrients
Altered Food Webs
Excess Competitors
Excess Predators

Sources of stressors were also discussed in this chapter. Again we have attempted to identify those we think represent the greatest threats, although we must note that every moderate source is also problematic and requires management. For example, “Livestock and Poultry” is listed as a moderate stressor source partly because it is expected that the agricultural land area of the Etowah will decline over time as suburban and urban land cover increases. However, there are individual streams in the Etowah where the paramount problem is unrestricted cattle access. Similarly, wastewater treatment plants are probably the greatest stressor sources for other streams. The sources classified as “major”, however, are all very widespread, impacting virtually all streams in the developing portions of the basin. Note that “Historic Sediment” is omitted from this list because it is not an ultimate stressor source, but rather a mechanism whereby impervious surfaces impact streams.

Major Sources of Stressors
Poor Riparian Buffers
Construction
Impervious Surfaces/Stormwater
Reservoirs

Moderate Sources of Stressors
Point Sources
Historic Sediment
Use of Pesticides and Fertilizer
Livestock & Poultry
Road Crossings
Invasive Species Introductions

The next chapter discusses tools available for managing each of these sources of stressors.

Table 2-1. Nonindigenous fish of the Etowah drainage (Adapted from Burkhead *et al.* 1997).

Common name	Family	Scientific Name
threadfin shad	Clupeidae	*Dorosoma petenense*
grass carp[a]	Cyprinidae	*Ctenopharnygodon idella*
red shiner	Cyprinidae	*Cyprinella lutrensis*
common carp[a]	Cyprinidae	*Cyprinus carpio*
bluntnose minnow	Cyprinidae	*Pimephales notatus*
rainbow trout	Salmonidae	*Oncorhynchus mykiss*
brown trout[a]	Salmonidae	*Salmo trutta*
brook trout[b]	Salmonidae	*Salvelinus fontinalis*
white bass	Moronidae	*Morone chrysops*
yellow bass[b]	Moronidae	*M. mississippiensis*
striped bass	Moronidae	*M. saxatilis*
hybrid bass[b]	Moronidae	*M. chrysops* x *M. saxatilis*
redbreast sunfish	Centrarchidae	*Lepomis auritus*

[a] Introduced into the United States
[b] These fish species, although thought to occur within the Etowah system, are not recorded in the collections database at the University of Georgia.

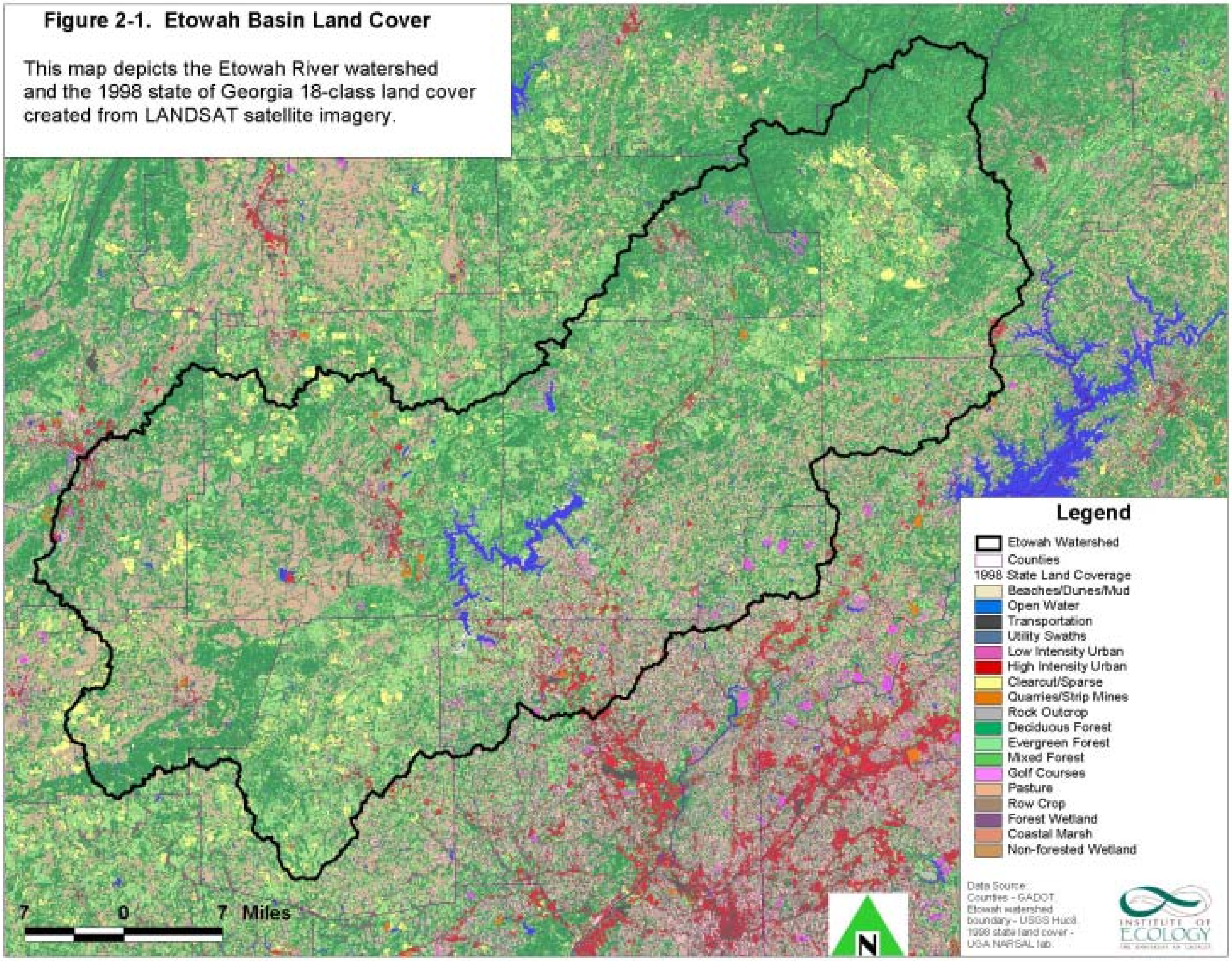
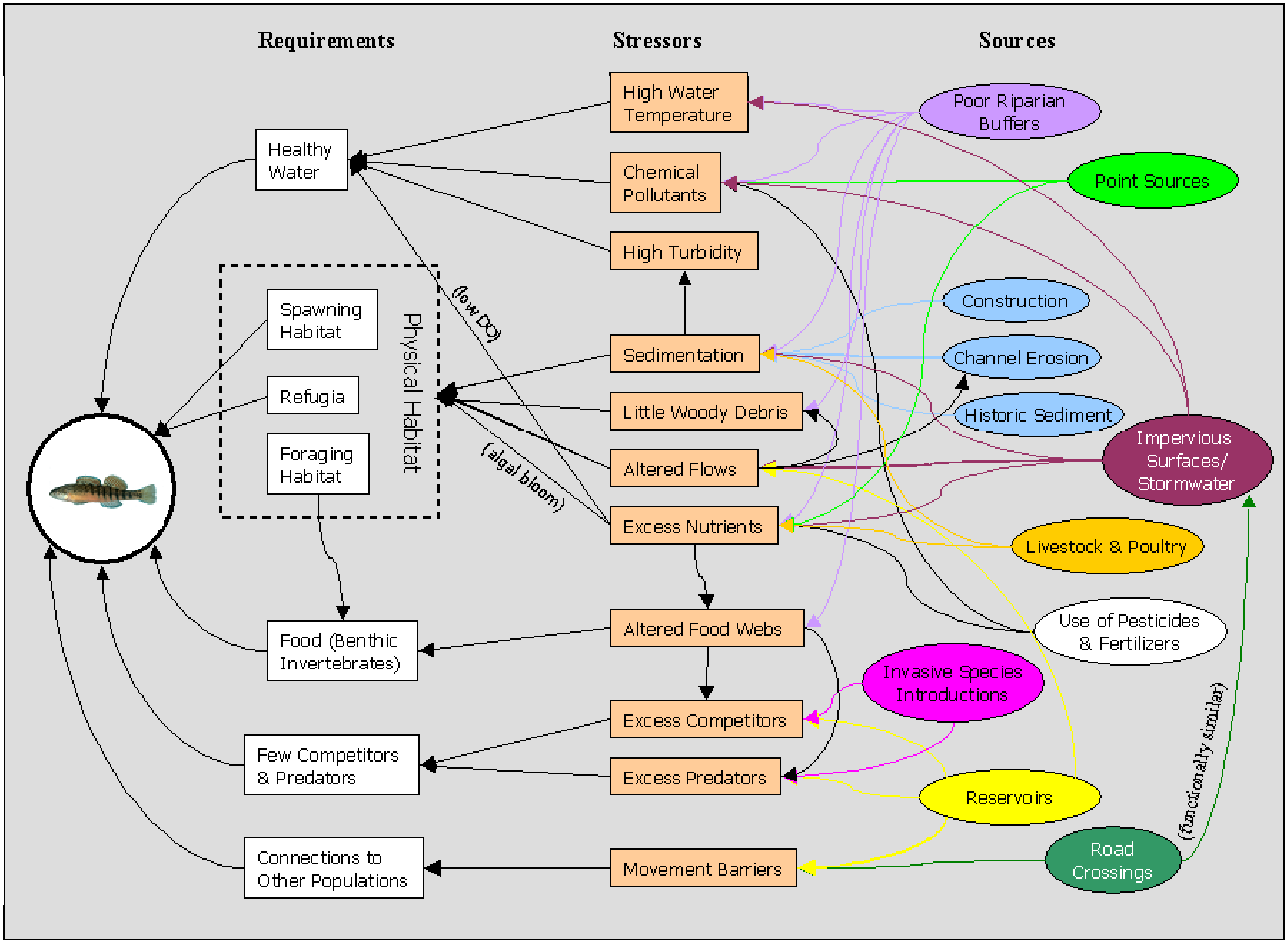


Figure 2-1. Etowah Basin Land Cover
This map depicts the Etowah River watershed and the 1998 state of Georgia 18-class land cover created from LANDSAT satellite imagery.
Legend
Etowah Watershed
Counties
1998 State Land Coverage
Beaches/Dunes/Mud
Open Water
Transportation
Utility Swaths
Low Intensity Urban
High Intensity Urban
Clearcut/Sparse
Quarries/Strip Mines
Rock Outcrop
Deciduous Forest
Evergreen Forest
Mixed Forest
Golf Courses
Pasture
Row Crop
Forest Wetland
Coastal Marsh
Non-forested Wetland
Data Source:
Counties - GADOT
Etowah watershed boundary - USGS Huc8
1998 state land cover - UGA NARSAL lab.
INSTITUTE OF ECOLOGY
7 0 7 Miles
N

Figure 2-2. Conceptual Model of Stressors to Imperiled Fishes in the Etowah Basin



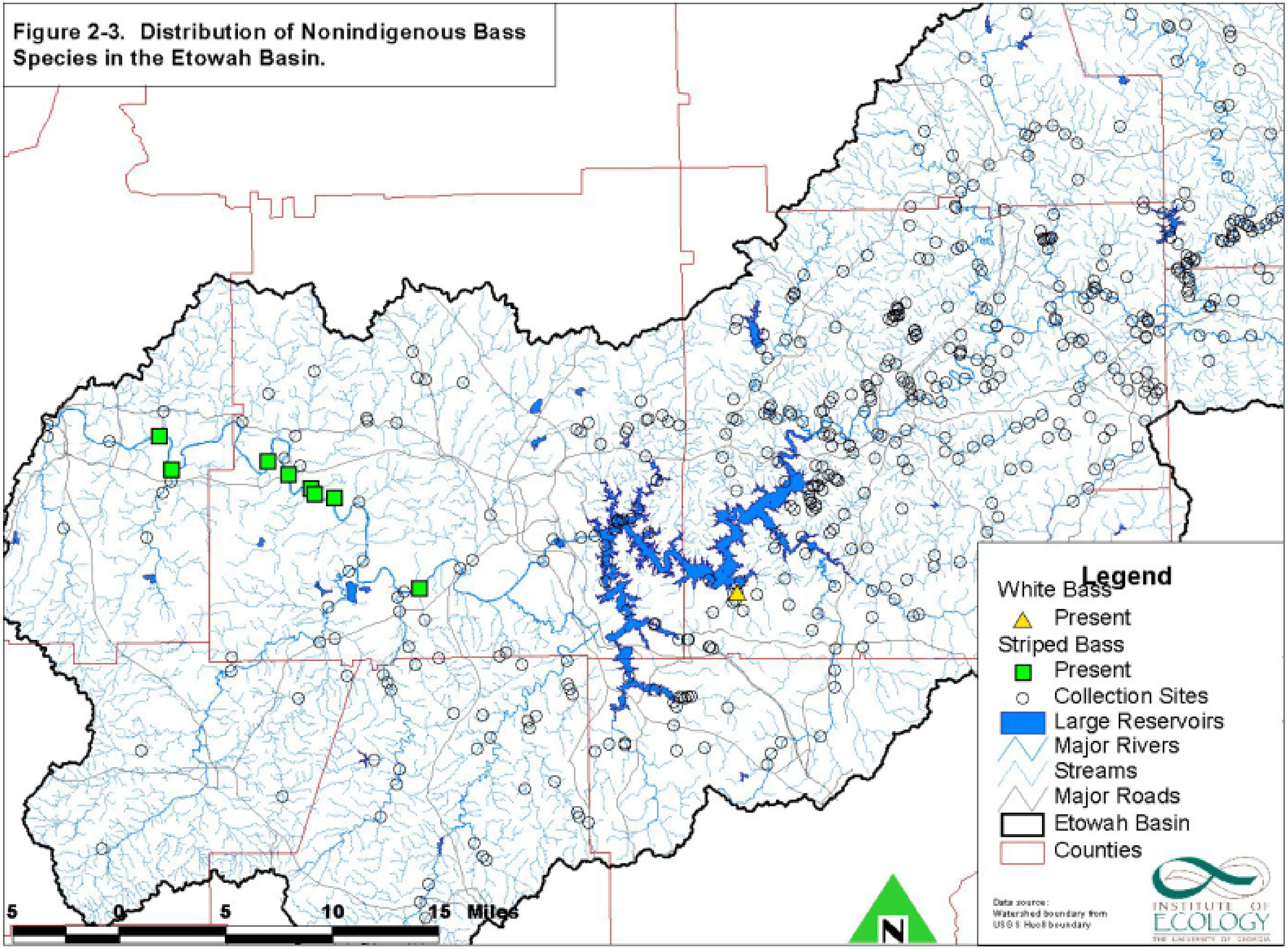


Figure 2-3. Distribution of Nonindigenous Bass Species in the Etowah Basin.
Legend
White Bass
Present
Striped Bass
Present
Collection Sites
Large Reservoirs
Major Rivers
Streams
Major Roads
Etowah Basin
Counties
5 0 5 10 15 Miles
N
INSTITUTE OF ECOLOGY

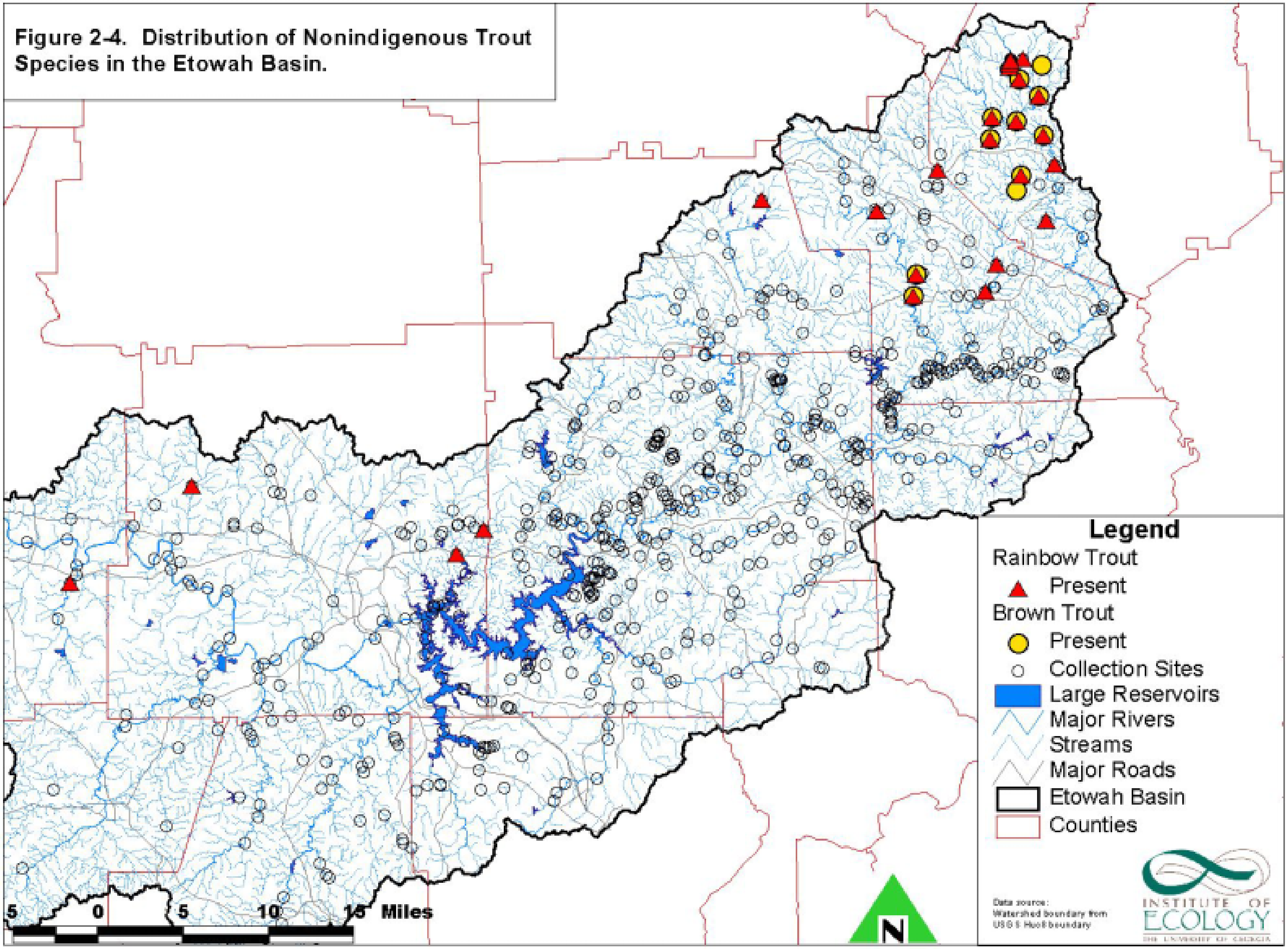


Figure 2-4. Distribution of Nonindigenous Trout Species in the Etowah Basin.
Legend
Rainbow Trout
Present
Brown Trout
Present
Collection Sites
Large Reservoirs
Major Rivers
Streams
Major Roads
Etowah Basin
Counties
5 0 5 10 15 Miles
N
INSTITUTE OF ECOLOGY

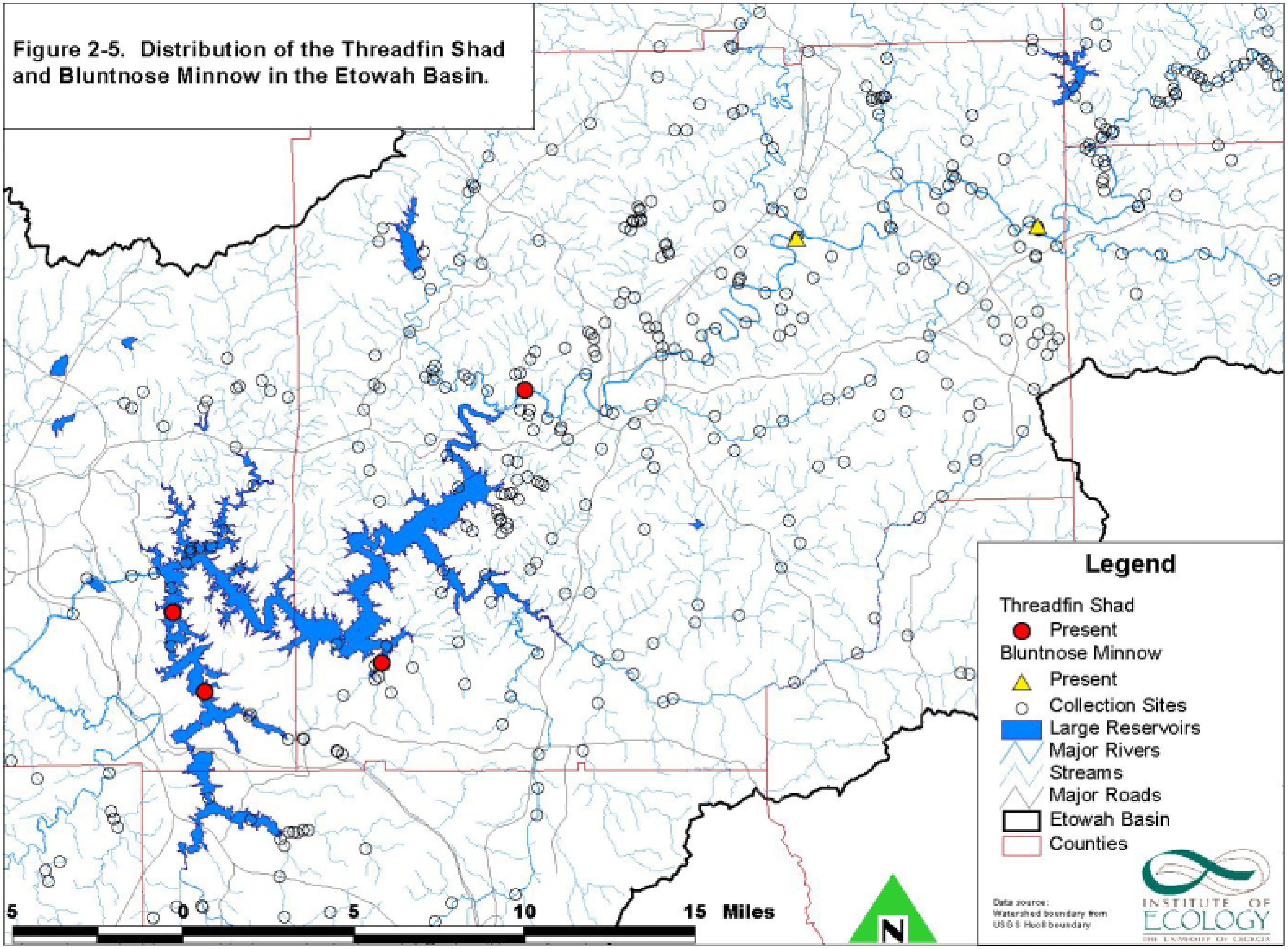


Figure 2-5. Distribution of the Threadfin Shad and Bluntnose Minnow in the Etowah Basin.

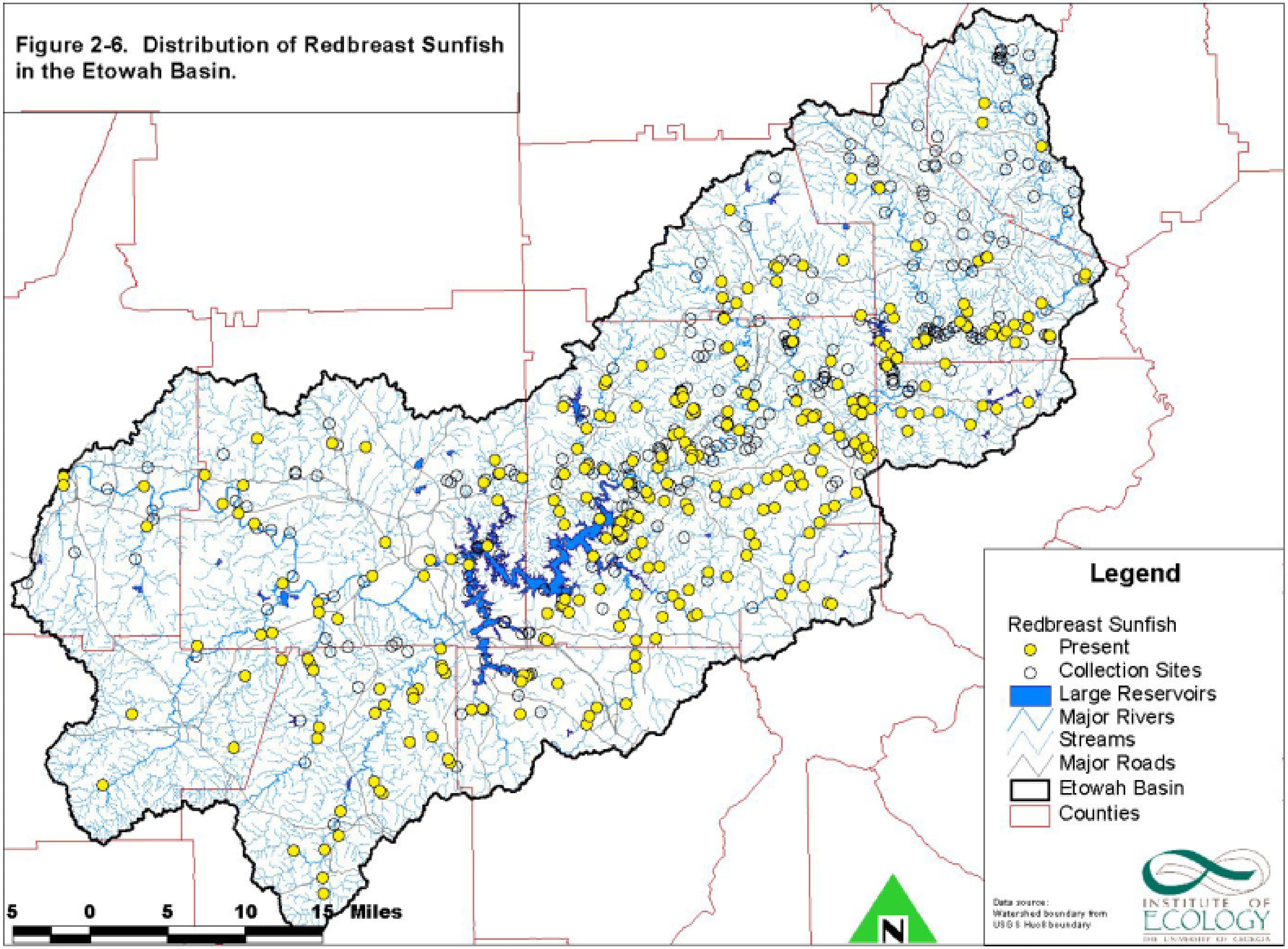


Figure 2-6. Distribution of Redbreast Sunfish in the Etowah Basin.

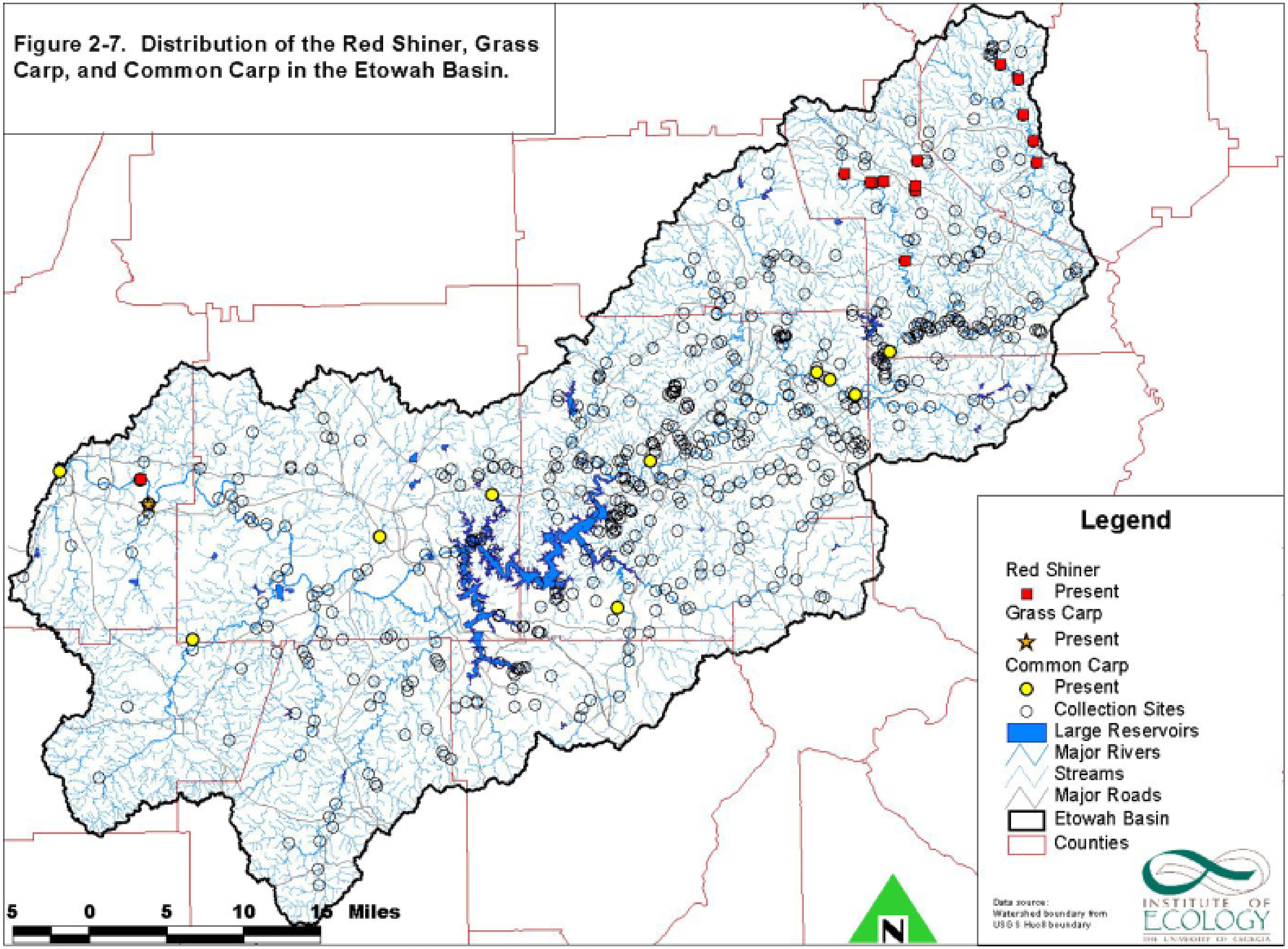


Figure 2-7. Distribution of the Red Shiner, Grass Carp, and Common Carp in the Etowah Basin.
Legend
Red Shiner
Present
Grass Carp
Present
Common Carp
Present
Collection Sites
Large Reservoirs
Major Rivers
Streams
Major Roads
Etowah Basin
Counties
5 0 5 10 15 Miles
N
INSTITUTE OF ECOLOGY

III. Tools to Minimize Stressors and Protect Aquatic Resources

There are as many ways to manage growth and protect natural resources as there are local governments and local ordinances. We have attempted to summarize the available approaches as a set of tools. The table below shows which tools might be appropriate for managing the various stressors. Each of the tools is then briefly discussed.

Sources of Stressor	**Management Tools**
Poor Riparian Buffers	Riparian Buffer Ordinance Acquisition and Preservation Stream Restoration Stream Mitigation Banking Conservation Subdivision Ordinance
Point Sources	Improved NPDES* Permits NPDES Permit Enforcement
Construction	Erosion & Sedimentation Ordinance
Channel Erosion	Stream Restoration Stream Mitigation Banking (see Impervious Surfaces/Stormwater)
Historic Sediment	(none recommended)
Impervious Surfaces/Stormwater	Progressive Stormwater Management Ordinance Conservation Subdivision Ordinance Acquisition and Preservation Conservation Planning
Use of Pesticides & Fertilizer	Agricultural Management Public Education
Livestock Production	Agricultural Management
Invasive Species Introductions	(none recommended)
Reservoirs	Drinking Water Supply Planning Small Reservoir Regulation Changes to Allatoona Dam Flow Management
Road Crossings	Road Crossing Guidelines

*National Pollutant Discharge Elimination System, a provision of the Clean Water Act.

Riparian Buffer Ordinance

Riparian buffers, also known as stream buffers and protected stream corridors, are areas along streams, rivers and lakes that are preserved in natural vegetation to protect water quality and to provide other benefits. For larger streams and rivers the buffer can be the floodplain; for smaller tributaries that lack an active floodplain, the buffer is the land adjacent to the stream.

Riparian buffers can be protected by regulation or by acquisition. The Erosion and Sedimentation Act protects all Georgia streams (with a defined channel) with a minimum buffer of 25 feet; streams supporting trout are given 50 ft buffers. The Georgia Planning Act compels local governments to establish wider buffers of up to 100 ft, with an additional 50 ft setback for impervious surfaces, on water supply watersheds of less than 100 square mile drainage area. At the time of this writing these regulations were under review by the Georgia Department of Community Affairs and Environmental Protection Division. In addition, many local governments have opted to establish their own riparian buffer regulations. Cherokee County requires buffers of 50 ft width on all perennial streamsand 100 ft on the Etowah mainstem. Cobb County protects buffers of 50 to 200 ft, depending on the size and type of stream. Forsyth County requires 50 ft buffers on its streams, while Fulton County requires 75 ft buffers.

It is important to note that the regulatory approach is only good for protecting buffers on developing lands, not lands that have already been developed (Wenger and Fowler 2000). In some cases it is highly desirable to "retrofit" buffers in urban and suburban areas to improve aquatic habitat quality. Ways to do this include purchasing the land, purchasing the development rights to the land, or protecting it under a stream mitigation programs. These methods are described elsewhere in this chapter.

Likewise, to our knowledge no local government in Georgia has protected buffers on agricultural lands. This is likely partially due to the standard practice of exempting agriculture from local regulation and to the perceived political backlash that would result. In 2001, opposition to the implementation of the 100 ft water supply watershed buffers described in the previous paragraph led to such a backlash in North Georgia counties that state agencies suspended enforcement of the rule pending review. On the other hand, studies have shown that buffers are especially effective and desirable on agricultural land (many summarized in Wenger 1999). Some federal incentive and subsidy programs encourage the use of buffers, but problems remain, as evidenced by locations in the Etowah basin where cattle have free access to streams and rivers. This is again a case where acquisition or stream mitigation must be used to improve and protect these sites.

Acquisition and Preservation

In many cases the best way to protect a stream is to protect its watershed. This is especially appropriate for many of the less developed watersheds in the Etowah that support healthy populations of Cherokee darters, holiday darters and Etowah darters. Ideally, land should be acquired and permanently preserved through the use of a legal tool such as a conservation easement. Acquisition is not limited to outright purchase, but can also include purchase of development rights, which may be less expensive. Local governments, state governments, the federal government and various private organizations all have a potential role to play in acquiring and preserving critical lands in the Etowah.

Fee Simple Acquisition

Fee simple acquisition is the purchase of a property in its entirety, with no encumbrances of any kind on the deed. It provides the most complete form of land ownership, and gives the owner the greatest degree of flexibility. Fee simple acquisition can be very expensive, however. It is the best choice for properties to be used for parks, trails, or other uses where public access is necessary. For many types of land, such as riparian corridors protected mainly for water quality purposes, public access is unnecessary or even undesirable. In these cases, it may make sense to acquire only development rights or to use forms of land protection that do not require the expense of outright purchase in fee simple.

Purchase of Development Rights (PDRs)
It is possible to purchase partial interests in property rather than purchasing it in fee simple. This is done on a regular basis by governments and utilities in the establishment of utility corridors and access easements. It can also be used for conservation purposes. If just the development rights to a property are purchased, the public is given a legal assurance that the land will not be developed, meeting many open space protection goals. The land remains in private hands and can still be used for some purposes, such as forestry, the occupation of existing homes, and other terms specified in the agreement. With a PDR program, the acquisition costs and maintenance costs can be significantly lower, although there are less options in how the property can be used (e.g., public access is generally not possible).

Conservation Easements and Other Tools for Permanent Protection
When development rights are acquired, some kind of legal mechanism must be used to permanently protect the land. There are several options available, but one that provides the fullest legal protection and the most benefits to the landowner is conservation easement. This is a voluntary agreement between a property owner and a second party (the easement holder) that restricts the use of the property to protect natural or cultural resources. The easement holder, which can be a government body or a private conservation organization (e.g. a land trust), has the responsibility of monitoring the property and ensuring that the terms of the easement are met. There are significant federal tax benefits for donated conservation easements, although these tax breaks are not usually available if the easement was purchased. A reduction in property taxes and estate liability is also possible, as the fair market value of the property is likely to be lower when the development options are limited.

A restrictive covenant can also protect land in perpetuity if it is written in favor of a government entity or organization "holding land for use of the public" (O.C.G.A. Section 44-4-60). Since there has been no case law in Georgia to interpret the phrase "holding land for use of the public," the real meaning of this phrase is unclear. While lands protected for public access greenways and parks would certainly qualify, we do not know if lands protected for wildlife and water quality meet the requirement. If not, then the restrictive covenant cannot be permanent. Given the uncertainty, conservation easements remain the preferred tools for protecting lands from development.

Targets for Acquisition and Preservation.
Acquisition efforts should be targeted to those watersheds that currently support healthy, interconnected populations of imperiled species and have limited land development. Foremost among these watersheds are Amicalola Creek in Dawson County, Shoal Creek in Dawson County, Shoal Creek in Cherokee County, Sharp Mountain Creek in Cherokee and Pickens Counties and Raccoon Creek in Paulding County. The Dawson Forest tract in Dawson County, which is currently a wildlife management area but lacks permanent protection, represents a great opportunity for preservation. The headwaters of the Etowah are important as well, but are currently protected within the Chattahoochee National Forest. Watersheds and subwatersheds of the Etowah were prioritized for protection in a 2000 report (Freeman and Wenger 2000).

Stream Restoration

Within priority watersheds (see "Acquisition and Preservation", above), there are many subwatersheds and stream segments that are locally degraded. These are good candidates for restoration; once preserved they should also be permanently protected. Stream mitigation banking is an important tool for facilitating restoration of priority segments. Chapter Four of this report provides recommendations for stream segments suitable for restoration, based on an analysis of aerial photography. Restoration may also be desirable in the more degraded watersheds of the Etowah, both for the water quality benefits and for the downstream benefits to mainstem Etowah species.

Stream Mitigation Banking

Under Section 401 and 404 of the Clean Water Act, anyone who impacts wetlands, streams or rivers may be required to perform mitigation in the form of restoring, enhancing or permanently preserving similar resources. Some entrepreneurs, local governments and utilities have established mitigation banks: programs in which mitigation activities are performed by an independent party, who sells "credits" to those who are required to perform such work. This allows a developer, for example, to satisfy mitigation requirements by simply paying a mitigation bank the requisite amount to perform appropriate mitigation activities.

The Corps of Engineers authorizes mitigation banking in various cases: 1) where no feasible opportunities for mitigating at the development site are available, 2) where off-site mitigation is demonstrated to be more environmentally beneficial than on-site mitigation, 3) where impacts of development will be minor, or 4) where projects are linear in nature. Between October 2000 and June 2001, the Corps required mitigation of approximately 5,800 linear feet of streams and 69 acres of wetlands in North Georgia, according to Robin Goodloe of the U.S. Fish and Wildlife Service. Wetlands banks have been active in Georgia for a number of years, but banks focusing on stream mitigation are relatively new. One of the first is the Etowah River Stream Mitigation Bank in Forsyth County, which has already begun selling credits. The StreamBank, a private enterprise intended to provide services across North Georgia, has no approved mitigation projects to date. A third bank is undergoing review by the Corps, while a fourth is operated by the Georgia Department of Transportation (DOT) in Banks County exclusively for compensatory mitigation of DOT projects.

Stream buffer mitigation banks can be useful tools for restoring degraded riparian zones in priority watersheds, and also for permanently protecting high-quality buffers in priority watersheds. For this study, "priority watersheds" means those watersheds that support healthy populations of imperiled species and are not in immediate peril from development or other sources of degradation. The previously mentioned study by Freeman and Wenger (1999) attempted to identify such watersheds in the Etowah. In Section V of this report, we present results of a new study to identify stream reaches within selected priority watersheds that are especially suitable for mitigation activities. Stream mitigation banks that target these priority stream reaches will provide a greater benefit to imperiled species than those that target other stream reaches.

Conservation Subdivision Ordinance
Conservation subdivisions are residential or mixed-use developments in which homes are clustered on a portion of property, while the remainder of the tract is protected as open space. Conservation subdivisions represent a means of preserving significant areas of greenspace at little or no cost to taxpayers and providing increased variety in the housing market. Also, these subdivisions also provide infrastructure savings for developers. Clustering homes will reduce the total area of impervious surface, which will help protect aquatic habitat. In addition, conservation subdivision ordinances can include incentives for protecting wide riparian buffers, to provide further benefits.

Today, the main barriers to the use of conservation subdivisions are local regulations that require minimum lot sizes and restrict the flexibility of developers. An increasing number of local governments have addressed this problem by amending zoning codes and development regulations to encourage conservation subdivisions. Cherokee County was a pioneer in the passage of a conservation subdivision ordinance, amending its zoning code in 1997. The program has been quite successful in that many new developments are built under the conservation subdivision regulations. However, private citizens have criticized the program under the belief that it requires too little of developers, allowing them to place the badge of conservation subdivision on where the open space consists solely of undevelopable land. A review of the program is underway by staff at the UGA Institute of Ecology.

Cobb County has a conservation subdivision ordinance that has had less use. This is partly because the original version of the ordinance gave developers large density bonuses, which were unpopular with the public. Although the ordinance was later rewritten to reduce these bonuses, a public hearing is still required to develop a property as a conservation subdivision (although no hearing is required for a conventional development). This hearing provides an opportunity for public criticism that many developers would prefer to avoid. Nevertheless, Cobb County is home to some innovative projects, such as Macauley Properties' large mixed-use developments *Legacy Park* and *Ridenour*. Rural Lumpkin County boasts a conservation subdivision called Fern Park, despite the county's lack of a zoning code or comprehensive development regulations. In fact, the lack of these regulations greatly eases the regulatory hurdles inherent in developing a conservation subdivision. Forsyth County also has a conservation subdivision ordinance, but we have not yet reviewed it.

Conservation subdivisions have the potential to help protect aquatic habitat by preserving wide riparian buffers and reducing the amount of impervious surface in developments. Because they provide benefits to the developer, the public and to the local government with few drawbacks, they are a logical component of an overall habitat protection strategy. However, used alone they are unlikely to provide major benefits to aquatic species. More information on the use of conservation subdivision ordinances in Georgia is available in a publication of the Atlanta Regional Commission (Wenger and Fowler 2002).

Improved NPDES Permits
As noted in the previous chapter, a permit issued under the National Pollutant Discharge Elimination System (NPDES) may not regulate all contaminants that are discharged by the

permitted point source. In some cases this provides acceptable management; for example, the regulated contaminants may be the most significant problems, or they may serve as surrogates for other constituents. Other times, the omitted constituents may represent significant threats to water quality. Other permits may cover all contaminants of concern but may have concentration limits that are not sufficiently stringent to provide adequate water quality protection. In both cases it may be possible to alter the NPDES permit to correct the problem. We have not evaluated existing point source discharges to determine whether any of the permits need to be improved in this manner, but we plan such a review for 2002.

NPDES Permit Enforcement

A NPDES permit may be sufficiently rigorous to provide water quality protection, but the permittee may jeopardize aquatic resources by regularly violating its terms. If violations are suspected, it may be possible to appeal to the regulatory authorities to provide stronger enforcement. If this does not address the problem, it may be necessary to bring a lawsuit to ensure compliance. Although this may sound like a drastic step, it is important to remember that litigation is a vital and necessary component of environmental laws; the use of litigation does not represent a failure of law but the application of law. Note, however, that we have not identified any permit violations as part of this project.

Erosion and Sedimentation Ordinance

The Georgia Erosion and Sedimentation Control Act (GESCA) requires the use of best management practices in the management of runoff from construction sites larger than 1.1 acres. In August, 2000, the Environmental Protection Division (EPD) issued a General NPDES Stormwater Permit for Construction Activities in compliance with the Clean Water Act, which imposed a second set of requirements on construction sites of five acres or larger. The GESCA is administered through local governments that have passed an ordinance consistent with state requirements, or the EPD for local governments who have not accepted this responsibility. The NPDES permit, on the other hand, is administered directly by the EPD.

A 2001 review of Georgia's erosion and sedimentation control program by the Georgia Department of Audits and Accounts concluded that the Erosion and Sedimentation Act is sufficiently stringent but is not being implemented effectively (Georgia Department of Audits and Accounts 2001). The review found that many local governments were "allowing construction projects to operate without the required erosion and sedimentation controls." In visits to construction sites in Whitfield County, the auditors found that "severe water quality violations were noted at most sites" (Georgia Department of Audits and Accounts 2001).

Some local governments employ too few enforcement officers, while others fail to apply penalties and stop work orders when problems are identified. If enforcement officers are unable to visit all construction sites with sufficient frequency to identify problems, there is a need for more personnel. Providing funding for the requisite number of officers may be a problem, however, when local governments do not make erosion and sedimentation control a priority. This lack of political will is also often at the heart of a failure to apply penalties and stop work orders. Some local officials claim that their hands are tied by the state law, which requires them to issue warnings prior to levying fines and stop-work orders. In fact, the law authorizes enforcement authorities to issue stop work orders immediately if there is an "imminent threat to public health or waters of the state" (OCGA 12-7-12).

What will compel local governments to improve their enforcement? Jurisdictions that chronically fail to enforce their erosion and sedimentation ordinances may have their authority revoked by the state. This is hardly an adequate solution, however, since Georgia does not provide the EPD with the resources to accept this burden. At the time of this writing the EPD has numerous unfilled positions in the office charged with administering the NPDES permit, limiting its ability to critically review applications. Furthermore, the nature of erosion and sedimentation enforcement requires that officers be locally based, which makes local authorities the logical agents of enforcement. Local governments need to take this responsibility seriously and (a) devote sufficient resources to monitoring and (b) apply stiff penalties to violators. This change is only likely to occur under combined pressure from residents, advocacy organizations, and state agencies. Change may be accelerated if legal action is brought against local governments that fail in their enforcement duties.

Progressive Stormwater Management Ordinance

A stormwater management ordinance requires that runoff from a stabilized site be managed in some manner. Traditionally, the goal has been simply to provide an efficient drainage network that provides rapid conveyance, eliminates local ponding, and prevents downstream flooding (Ellis and Marsalek 1996). More recently many local governments have modified their stormwater ordinances to protect water quality and aquatic habitat as well. In part this is due to changes to federal law that now require National Pollutant Discharge Elimination System (NPDES) permits for municipal stormwater systems. When we refer to a progressive stormwater management ordinance in this document, we mean an ordinance that requires stormwater to be handled in a way that minimizes alterations to stream flows and does not greatly degrade water quality.

The most efficient way to manage stormwater is to minimize runoff at the source by reducing the amount of impervious surfaces. Many of the other tools discussed in this chapter use this approach; conservation subdivision ordinances do this on the site level, while conservation planning does this on the regional level. A good stormwater ordinance will also provide incentives for good site design that minimizes impervious surfaces. Research by the Center for Watershed Protection has shown that residential and commercial sites can often be redesigned to reduce impervious surfaces by as much as 35% (Caraco *et al.* 1998). An alternative way to reduce impervious surfaces is to use porous paving that permits infiltration of rainfall through the pavement. Porous paving is not widely used in Georgia, partly due to concerns about the long-term effectiveness and durability of the less expensive types, such as porous asphalt. Other types, such as block pavers, are effective but relatively expensive, limiting their use to special applications (Appendix C in Brown and Caldwell *et al.* 2001). Nevertheless, there are numerous examples of the use of porous paving in Georgia (Appendix C in Brown and Caldwell *et al.* 2001).

The next best way to deal with runoff is to encourage it to infiltrate into the soil as close as possible to where it was generated. Infiltration can be a near-perfect solution to the stormwater problem, because infiltrated water can be cleansed by soil, and infiltration maintains a natural hydrologic regime. Infiltration can sometimes be accomplished by channeling runoff to natural or landscaped vegetated areas on-site, called bioretention areas. Infiltration ponds, sometimes called retention ponds, can also be employed, but they may not be appropriate in all soils and often require significant maintenance for long-term effectiveness (Ferguson 1994). Use of any infiltration system requires proper design coupled with a good understanding of local soils, water tables and geology. If infiltration rates are too slow the soil may need to be modified or amended. If infiltration rates are exceptionally high or if there are preferential flow paths, groundwater contamination could occur (Ellis and Marsalek 1996).

While retention ponds are designed to allow infiltration, detention ponds are intended to hold water for short periods of time and then release it. Conventional stormwater detention is designed primarily to prevent downstream flooding and usually has little positive impact on aquatic habitat (Booth and Jackson 1997). If properly designed, however, detention ponds may play an important role in managing stormwater from developments with large amounts of impervious surface and limited opportunities for infiltration. Detention ponds must be designed to both treat water and to release water at a rate that approximates the pre-development flow and does not cause excessive channel scour (Booth and Jackson 1997).

The ideal stormwater management ordinance would require that sites be designed to minimize impervious surface, provide for infiltration of stormwater when possible, provide treatment of runoff to remove a majority of pollutants, and provide detention of runoff that protects stream channels and approximates pre-development flow patterns. The Atlanta Regional Commission has developed a stormwater design manual that recommends many of these goals and is in the process of creating a model stormwater ordinance. We intend to conduct further research in 2002-2003 to better understand how stormwater must be managed to protect aquatic habitat.

Conservation Planning

Growth management must be employed at both the site level and the county or regional level. At the site level, tools such as conservation subdivisions and buffer ordinances are effective at protecting strips of riparian land and small portions of watersheds. With luck these may be connected to form continuous riparian buffers and larger areas of open space. At the county level, planning is essential to protect large portions of watersheds and reduce the overall impervious surface coverage. We use the term "conservation planning" to describe the practice of targeting growth to areas where it is most suited, while providing disincentives to development in priority conservation areas.

While conservation planning provides obvious benefits for terrestrial ecosystems— critical terrestrial habitats can be placed off-limits— its benefits for aquatic ecosystems have not been definitively established. A 2000 study of a subwatershed of the Alcovy Basin (Walton and Newton Counties) compared the water quality impacts of a clustered pattern of development to a uniform sprawl pattern (Brown and Caldwell *et al.* 2001). The results showed that the clustered pattern resulted in better water quality because the overall amount of impervious cover was lower. The effects on aquatic habitat were not evaluated, however. The question is whether it is better to have a few high-density nodes of development, which are likely to cause significant aquatic habitat degradation on a few watersheds, or uniform low-density development, which is likely to cause some aquatic habitat degradation across all watersheds. We probably will not be able to answer this question properly until we have a better understanding of the thresholds at which sensitive species disappear from urban streams.

Aside from the issue of impacts to aquatic organisms, there are compelling economic and social benefits to conservation planning and node-based development. To list just a few:

- Road and utility networks are shorter, making them less expensive to build and maintain
- School busing expenses are lower
- Fire, ambulance and police services are less expensive and response times are shorter
- Higher population densities make public transit practical, providing more efficient commuting options and reducing automotive traffic.

Studies have found that the economic savings of managing growth can be large. A 1989 literature review found that the capital costs of the infrastructure to support low-density development were nearly double those of compact development (Frank 1989). In 1990, Virginia Beach completed a study comparing two development scenarios for the rapidly growing southern portion of the city. The study showed that a "smart growth" scenario (node-based development, with new development clustered in towns) would generate net annual tax revenues of $5.12 million, while a sprawl scenario would lead to an annual shortfall of $19.07 million (Siemen, Larsen & Purdy *et al.* 1990). Studies conducted in Florida, Arizona and Minnesota have reached similar conclusions (James Duncan and Associates 1989; Davis 2000; Center for Energy and Environment *et al.* 1999).

Transferable Development Rights Program

A transferable development rights (TDR) program is a tool that makes conservation planning more feasible by providing a form of compensation to landowners in areas designated for low-density development. With a TDR program, property owners in areas targeted for protection ("sending areas") can sell their development rights to property owners in areas designated for growth ("receiving areas"). Once development rights are sold, the properties are permanently protected with a conservation easement. A workable TDR program requires proper zoning of both sending and receiving areas and balancing of the supply and demand of development credits. Although there are several examples of successful TDR programs in other states, the tool has not yet been used in Georgia. One reason is that the state enabling legislation requires public hearings for every credit transfer, rather than just when the sending and receiving areas are established. In 2001 the Georgia General Assembly lifted this extra burden for TDR programs created by unified city-county governments. If it is lifted for other jurisdictions as well, a TDR program might be a viable tool for local governments in the Etowah basin.

Agricultural Management

Traditionally, most local governments do not regulate agriculture. To compel farmers to adopt more environmentally friendly practices, the federal and state government uses subsidies, incentives and advisory programs, rather than laws and ordinances. There are now numerous programs of this sort: the Conservation Reserve Program, the Environmental Quality Incentive Program, the Wetlands Reserve Program and the Conservation Reserve Enhancement Program. Additionally, soil and water conservation commissions, resource conservation and development agencies and the agricultural extension programs have programs to encourage environmentally friendly farming practices. It is clear that these programs have not fully solved the problems of agricultural pollution of aquatic systems in Georgia, judging by the number of agriculture-related talks at the most recent Georgia Water Resources Conference (Hatcher 2001).

There are three ways to address persistent problems of agricultural pollution in aquatic systems. The first is to continue to improve the recommendations and guidelines provided to the agricultural community by incorporating the best available science. For example, basing poultry litter application rates on phosphorus, rather than nitrogen, can reduce nutrient contamination of aquatic systems (Sharpley 1999). The second way is to provide increased economic incentives to the agricultural community, either through new programs, increased funding of existing programs, or simply participation in current programs. For example, the Conservation Reserve Enhancement Program—currently unused in Georgia—could be used to fund cattle exclusion projects. Finally, local governments may choose to place regulatory restrictions on certain activities, including limits on the size of concentrated animal feeding operations and limitations on cattle access to streams. This step can be politically difficult but by no means impossible.

Drinking Water Supply Planning

Most mid-sized and large reservoirs constructed today in Georgia are built primarily for drinking water supply. In many cases, however, there is not a thorough evaluation of alternatives to reservoir construction: a reservoir is assumed to be the only or best means of meeting increased demand. In 2001 representatives of water authorities, counties, and municipalities within the Etowah held meetings to discuss the need for, and location of, an “Upper Etowah Reservoir.” We suggest that such planning is premature. Prior to considering reservoir construction, the jurisdictions of the Etowah should (a) evaluate current and future water needs, (b) identify options for meeting these needs, and (c) consider the costs and benefits of each option. It may be that such a reservoir ultimately proves necessary, but given the significant impacts reservoirs have on aquatic fauna, it is critical to make the decision in light of all available alternatives.

Small Reservoir Construction Restrictions

A recent study has shown that small impoundments are ubiquitous across the landscape of Georgia, although they are generally unmapped and unrestricted (Merrill *et al.* 2001). Many new reservoirs are built as “amenity lakes”, features of golf courses and developments intended primarily for aesthetics, rather than water supply. Because they are usually constructed on small streams, these small impoundments have a disproportionate impact on Cherokee darters through direct habitat loss and population fragmentation. We believe that impoundments that serve no public purpose other than aesthetic should not be permitted on streams that are known to support populations of Cherokee darters. Even in stream segments outside the range of the Cherokee darter such impoundments should be strongly discouraged, due to their impacts on other fish species.

Changes to Allatoona Dam Flow Management

The flow from Allatoona Dam is currently managed by the Army Corps of Engineers for hydropower generation, water supply and recreation. There is no mandate to manage the flow to maintain natural stream habitat in the Lower Etowah, partly because there are no extant populations of imperiled species in the river. If flow were managed with consideration for the needs of all imperiled species in the Etowah, we believe that reintroduction efforts would have a reasonable chance of success. Recent public meetings on lake level management have focused on balancing water supply and recreational demands with hydropower generation needs. We suggest that the needs of aquatic species also become a priority.

Road Crossing Guidelines

Road crossings are associated with two stressors: (1) barriers to fish movement; and (2) stormwater runoff, since crossings can serve as conduits that channel runoff to streams. Local governments and the Georgia DOT can adopt guidelines for bridge construction contracts to minimize these impacts. Guidelines should indicate when a culvert is acceptable, the type of culvert that can be used, and the type of drainage system. In general, the goal should be to eliminate the use of traditional culverts, use freespan bridges whenever possible, and minimize the amount of runoff that is shunted into the stream. Some preliminary recommendations related to culvert use were developed by students in the UGA Institute of Ecology Etowah Practicum (Baggett *et al.* 2001).

IV. Riparian Restoration Sites

To identify possible locations for riparian buffer restoration and preservation, we analyzed the riparian cover of streams in several major tributary systems of the Etowah: Shoal Creek (Cherokee County), Sharp Mountain Creek and Shoal Creek (Dawson County). These systems were selected in part because they were previously identified as priorities for preservation (Freeman and Wenger 1999). Other tributary systems, such as Long Swamp Creek and Raccoon Creek, would also be appropriate for analysis but were omitted due to time and funding constraints. Some smaller tributaries were also analyzed separately as part of an effort to identify potential mitigation sites for the Hickory Log Creek reservoir. The results of these analyses are included as well. Figure 1 shows the study watersheds.

Methods

We used digital color infrared aerial photographs ("CIRs") from the U.S. Geological Survey's National Aerial Photography Program (NAPP) as our source for riparian cover data. The CIRs were selected as a data source because they are based on relatively recent photographs (1999) and have higher resolution than satellite imagery. Using ESRI Arcview 3.2 GIS software, we overlaid a shapefile of 1:24,000 scale vector stream data from the Georgia Department of Transportation (reference) on top of the CIRs. Based on the width of the adjacent riparian forest, we assigned a buffer ranking value (table 4-1) to each stream segment for both river right and river left. To ensure greater consistency in determining buffer width, guidelines were placed along either side of the streams at a distance of 30m using the "buffer" routine in Arcview. Segments were subdivided whenever there was a significant change in the width of the riparian forest on either side, so that each segment had only one buffer type on each side and therefore one score. The mean of the river right and river left scores was taken for every segment, and the mean for each subwatershed was also determined. The watersheds used in this analysis are shown in Figure 4-1.

It was apparent that there were registration problems between the CIRs and the stream shapefile, although both data sources were in the same projection. In other words, the features on the one file do not line up consistently with features on the other. In some instances, the stream shapefile showed a channel appearing as far as 100 m from the channel pictured in the infrared photograph. Rather than assess the forest cover alongside the stream as shown in the shapefile, which would have resulted in errors, we assessed the forest cover along the channel as it appeared in the CIR, but assigned scores as described above. In cases where there was no channel visible in the CIR, the stream in the shapefile was used as a guide and assumed to be correct.

To determine the accuracy of the method, we randomly selected 20 sites for ground-truthing from the 295 road crossings that occurred within the study area. One site was rejected due to access problems (it was a stream crossed by I-575), and another rejected because the stream was not flowing and could not be accurately located. Site 276 had to be discarded due to the very poor registration of the stream coverage with the aerial photography. Site visits were made to the remaining 18 sites (Figure 4-2, Table 4-2) to determine actual forest cover on river left and river right of each stream immediately above the road crossing. A score was assigned to each site using the same buffer scoring system used in the analysis of the CIR imagery. In some cases, it was impossible to make precise measurements of buffer width, due to impediments such as cattle fencing (sites 78 and 51), dogs (site 210) or exceedingly dense understory (site 97), and width was estimated. We compared the scores assigned in the field (actual values) to the scores assigned to the same locations using the CIRs.

Results

The results of the CIR scoring are shown in Figures 4-3 through 4-7 and displayed in Table 4-3. On the maps, classified streams are color-coded to show total buffer score (sum of river left and river right values) for each segment, with red indicating poorly buffered streams (score of 1-4), yellow moderately buffered (score of 5-7), and green well buffered (score of 8-10). The color infrared photography used in the analysis is displayed in the background. The average score for each subwatershed is shown in each subwatershed's figure. The majority of stream segments scored in the high range, although nearly every subwatershed included at least some low-scoring segments as well. Figure 4-8 shows all ranked segments where the buffer on either river right or river left scored a one (no buffer) or two (scattered trees only). These can be considered candidate locations for restoration.

Table 4-4 shows a comparison of the 18 actual (ground-truthed) scores and the scores for the same sites predicted using color infrared analysis. Figure 4-9 shows the frequency of differences between predicted and actual scores (i.e., how many sites scored the same, how many showed a difference of one point, etc). Approximately 90% of sites scored the same or showed a difference of only one point, but 10% of sites showed a difference of two or three points. A two-tailed Wilcoxon Signed Names Test was used to test for significant differences between the predicted and actual scores. There was no significant difference at the p=0.5 level, but there was a significant difference at the p=0.10 level.

Discussion & Conclusions

Accuracy of the Method

The method of using aerial photography for estimating the quality of stream buffers proved reasonably accurate, but there were significant errors. The major problem was the poor registration between the CIR imagery and the stream shapefile. In cases where the difference was significant and the stream channel was not readily apparent in the imagery, the estimate of buffer condition amounted to little more than a guess. The registration problem could be reduced through the use of digital projection correction techniques. We did not use such methods for two reasons: (1) we wanted to determine the accuracy of the scoring method using "off-the-shelf" data and methods that can be readily replicated by other users and (2) we were constrained by time and budget limitations.

A second potential source of error is variation in the way different people scored streams, since some subjectivity is inherent in the method. This error can be minimized through good training, good quality control methods, and use of visual aids such as lines that parallel streams at distances of 10m and 30m. The best quality control method is to have the different users crosscheck each other's work, to ensure consistency. In our study one person performed the vast majority of the work, and also checked the work of the other two technicians. Inaccuracies can also arise from errors in the stream shapefiles themselves, which are quite common. Sometimes these can be corrected using the aerial photography, but occasionally problems may go unnoticed. Even in a short time, imagery may also become out-dated causing additional errors in classification. Finally, using aerial photography can slightly overestimate buffer width because it measures the width of the canopy, which extends slightly farther than the treeline.

Field verification showed that more than half of all streams were scored differently in the field than they were using the CIRs, although this difference was only one point in most cases. Ten percent of errors were serious, with the scores differing by two to three points; this is enough to lead to a misinterpretation of buffer condition. Despite the error, we believe there is great value to this method. It provides far more accuracy and resolution than the use of satellite imagery, most of which uses 30-m pixels. This is insufficient to detect the presence of narrow buffers or to resolve differences in buffer width. It is also more suitable to regional scale analyses than field evaluations, which are usually only practical on a limited scale.

Sites for Restoration

The main purpose of this exercise was to identify candidate sites for stream bank restoration, enhancement and preservation. This information is especially useful for the locating mitigation sites under the Clean Water Action Section 404 permitting program. All of the sample watersheds, with the exception of Hickory Log Creek and some direct tributaries, are in systems that had previously been identified as priorities for protection (Freeman and Wenger 1999). These are considered priorities because they support known populations of the federally threatened Cherokee darter and because at least portions of the watersheds are undeveloped and support healthy aquatic habitat. These systems represent the best opportunity for preserving viable breeding populations of Cherokee darters and other species. In addition, maintaining these watersheds in healthy condition will help support species that live in the mainstem of the Etowah. It is essential that any development or futher degradation within these watersheds be offset by improvements to currently degraded stream reaches, such as those identified in this project.

In the Shoal Creek (Cherokee County) system, the greatest benefits from restoration and enhancement are likely to accrue in Central Shoal Creek and McCanless Creek subwatersheds. McCrory Creek and Upper Shoal Creek are each separated from the rest of the system by an impoundment that is likely to serve as a barrier to fish movement. In a sense, this limits some of the benefits to the area isolated by the reservoir, although some water quality benefits will extend downstream. Many of the streams with poor buffers in the Shoal Creek system flow through agricultural lands. Streams draining the massive Lake Arrowhead development appear to be well buffered, however.

In the Sharp Mountain Creek system, which drains both Pickens and Cherokee counties, there are many opportunities for improving streams by restoring poor buffers. Land uses along these degraded streams include both agricultural and urban/suburban development. Again, enhancing streams isolated by impoundments will provide less benefit than restoring streams that are fully connected to the rest of the watershed.

In the Shoal Creek (Dawson County) system, poorly buffered streams are mostly limited to the Pigeon Creek, Burt Creek and Flat Creek subwatersheds. Impacted streams in Pigeon Creek are mostly agricultural; those in Flat Creek are in the town of Dawsonville, and those in Burt Creek are impacted by the Gold Creek golf course. The Pigeon Creek subwatershed is the logical first choice for buffer enhancement activities, considering the difficulty in acquiring and protecting riparian areas within urban areas or golf courses.

Hickory Log Creek and other direct tributaries were analyzed as part of a separate effort to identify potential mitigation sites for the Hickory Log Creek reservoir, which will inundate the much of Hickory Log Creek and many of its tributaries. The owners of the reservoir may wish to enhance the poorly buffered streams above the pool (these are mostly on agricultural lands) to protect water quality, but this will have little benefit for aquatic species isolated by the reservoir. Restoration of streams in Smithwick Creek, Puckett Creek, and unnamed watersheds that are direct tributaries of the Etowah will be beneficial, but perhaps not so much so as efforts within the larger tributary systems described above.

Table 4-1. Riparian Buffers Scoring System.

Riparian Buffer Description	Riparian Buffer Score
No riparian buffer	1
Few trees	2
Patchy buffer	3
Buffer 10-30m	4
Buffer >30m	5

Table 4-2. Groundtruthing Sites.

Site Number	Locality
Site 5	Shoal Creek tributary at Greenway Rd. in Lumpkin Co.
Site 2	Pigeon Creek tributary at Three Knots Rd / Tannell Hall Rd. in Dawson Co.
Site 17	Shoal Creek tributary at Harmony Church Rd. in Dawson Co.
Site 276	Shoal Creek tributary at Apple Ridge #1 in Dawson Co.*
Site 97	Polecat Branch tributary at Bell St. in Pickens Co.
Site 78	Sharp Mountain Creek at Mineral Springs Rd. in Pickens Co.
Site 101	Rock Creek tributary at Gregory Dr. in Pickens Co.
Site 123	McCory Creek tributary at Fincher Dr. in Cherokee Co.
Site 228	Shoal Creek tributary at Old Mill Lane off of Little Refugee Rd. in Cherokee Co.
Site 268	Little Shoal Creek tributary at College Pkwy / HWY 108 in Cherokee Co.
Site 214	Puckett Creek tributary at Reinhardt College Pkwy. in Cherokee Co.
Site 210	Puckett Creek tributary at Puckett Creek Rd. in Cherokee Co.
Site 171	Unnamed Etowah River tributary at Canton Hwy. in Cherokee Co.
Site 170	Unnamed Etowah River tributary at Canton Hwy. in Cherokee Co.
Site 176	Murphy Creek tributary at Long Rd. in Cherokee Co.
Site 118	Soap Creek tributary at Damascus Rd. in Pickens Co.
Site 105	Sharp Mountain Creek at Cagle Mill Rd. South
Site 51	Buzzard Flapper River tributary at Julius Bridge Rd. in Cherokee Co.

**Omitted from analyses due to serious data registration problems.*

Table 4-3. Riparian Buffer Scores by Subwatershed.

Sub-watershed	Average Buffer Score	Total Stream Length (km)	% Poor	% Good
Shoal Creek in Cherokee Co.				
Upper Shoal Creek	9.64	39.64	1.76%	96.94%
Central Shoal Creek	8.54	53.45	11.62%	77.19%
McCory Creek	8.65	21.10	9.19%	77.65%
McCanless Creek	8.42	39.44	15.13%	73.72%
Lake Arrowhead	9.70	24.21	1.82%	95.66%
Lower Shoal Creek	9.60	39.05	1.15%	91.25%
Gorman Branch	10	13.72	0.00%	100.00%
Little Shoal Creek	9.6	18.71	3.71	94.10%
Little Creek	9.19	10.82	0.00%	82.10%
Shoal Creek in Dawson Co.				
Pigeon Creek	8.84	34.28	8.36%	82.06%
Sweetwater Creek	9.75	22.66	1.10%	95.82%
Upper Shoal Creek	9.52	34.74	1.80%	92.42%
Burt Creek	8.26	21.60	14.40%	76.59%
Flat Creek	8.92	8.36	3.08%	82.28%
Unnamed Tributary	9.96	13.06	0.00%	98.94%
Lower Shoal Creek	9	41.44	1.55%	95.06%
Sharp Mt. Creek				
Murphy Creek	8.53	23.09	13.70%	75.80%
Soap Creek	8.85	54.76	5.68%	80.53%
Unnamed Tributary 1	6.93	27.67	24.38%	61.93%
Lower Sharp Mt. Cr.	9.16	34.49	7.36%	88.85%
Upper Sharp Mt. Cr.	8.36	47.15	12.56%	72.97%
Padgett Creek	9.15	14.89	10.04%	85.46%
Polecat Branch	7.94	22.03	12.56%	66.79%
Unnamed Tributary 2	8.24	43.00	10.62%	70.86%
Rock Creek	9.15	37.43	5.40%	87.63%
Mainstem Tributaries				
Puckett Creek	9.3	13.76	4.99%	92.37%
Upper Smithwick Creek	8.1	17.22	11.35%	67.95%
Lower Smithwick Creek	8.27	42.11	13.52%	72.21%
Direct Tributary 4	8.08	18.33	15.24%	69.70%
Hickory Log Creek	9.1	44.04	3.36%	82.94%

Table 4-4. Predicted vs. Actual (Field) Riparian Scores for River Right (RR), River Left (RL) and Combined Total.

Site #	Width RR Buffer (m)	Field RR score	Predicted RR score	Width RL Buffer (m)	Field RL score	Predicted RL score	Field Total	Predicted Total
5	>30	5	5	3.9	5	5	10	10
2	0	1	4	0	1	2	2	6
17	>30	5	5	15.8	4	5	9	10
97	>30	5	5	>30	5	5	10	10
78	~3-5	2	2	~3-5	2	5	4	7
101	8.5	3	3	20	4	5	7	8
123	10.6	4	4	1.0	2	4	6	8
228	>30	5	5	>30	5	5	10	10
268	>30	5	5	>30	5	5	10	10
214	0	1	1	0	1	1	2	2
210	0	1	2	~8-10	3	2	4	4
171	21.65	4	3	1.5	2	3	6	6
170	5.0	2	1	8.5	2	1	4	2
176	0	1	2	0	1	2	2	4
118	>30	5	5	>30	5	5	10	10
105	0	1	2	0	1	2	2	4
51	>30	5	5	~20	4	5	9	10

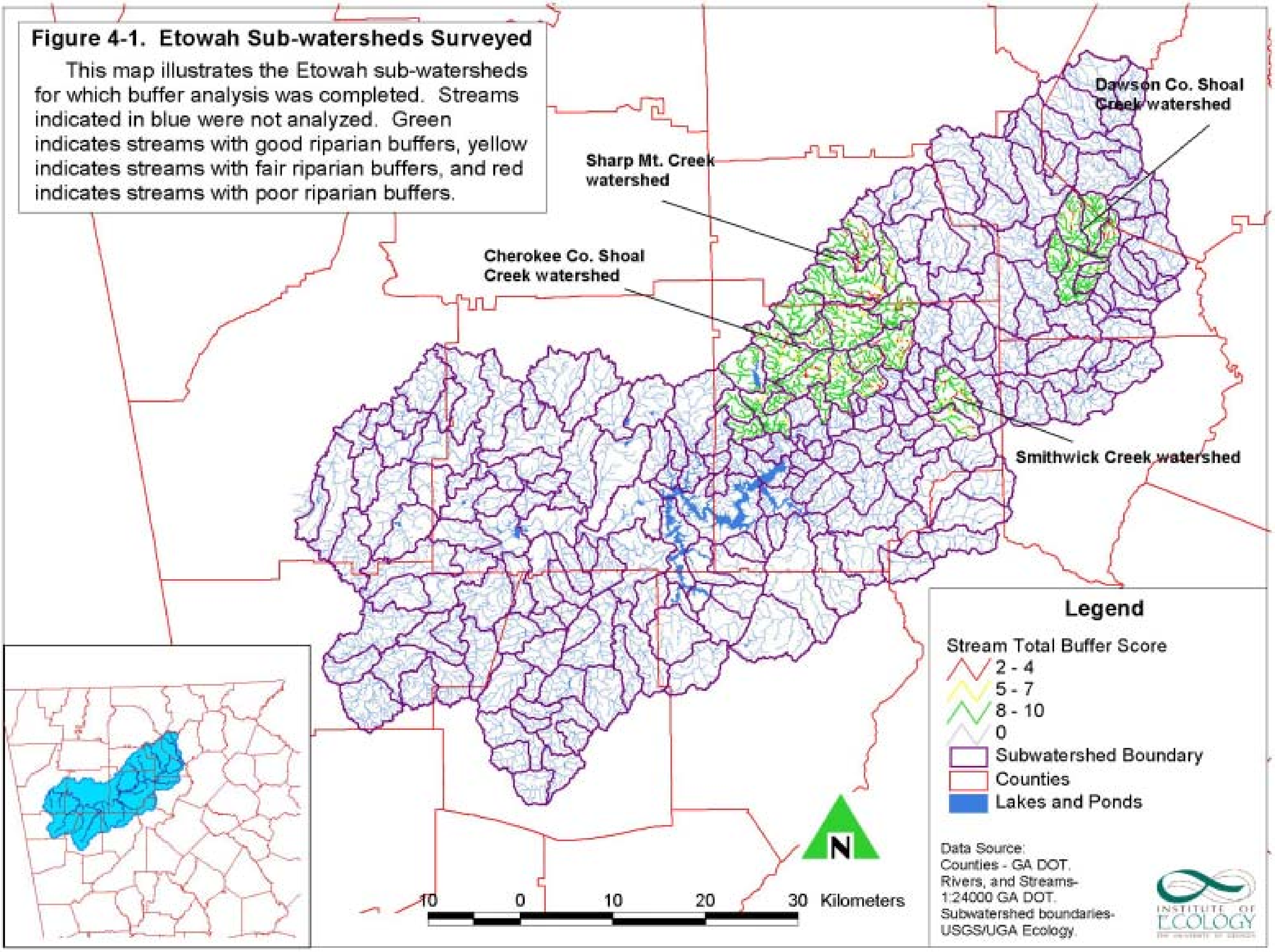


Figure 4-1. Etowah Sub-watersheds Surveyed
This map illustrates the Etowah sub-watersheds for which buffer analysis was completed. Streams indicated in blue were not analyzed. Green indicates streams with good riparian buffers, yellow indicates streams with fair riparian buffers, and red indicates streams with poor riparian buffers.
Dawson Co. Shoal Creek watershed
Sharp Mt. Creek watershed
Cherokee Co. Shoal Creek watershed
Smithwick Creek watershed
Legend
Stream Total Buffer Score
2 - 4
5 - 7
8 - 10
0
Subwatershed Boundary
Counties
Lakes and Ponds
N
10 0 10 20 30 Kilometers
Data Source:
Counties - GA DOT.
Rivers, and Streams-
1:24000 GA DOT.
Subwatershed boundaries-
USGS/UGA Ecology.
INSTITUTE OF ECOLOGY

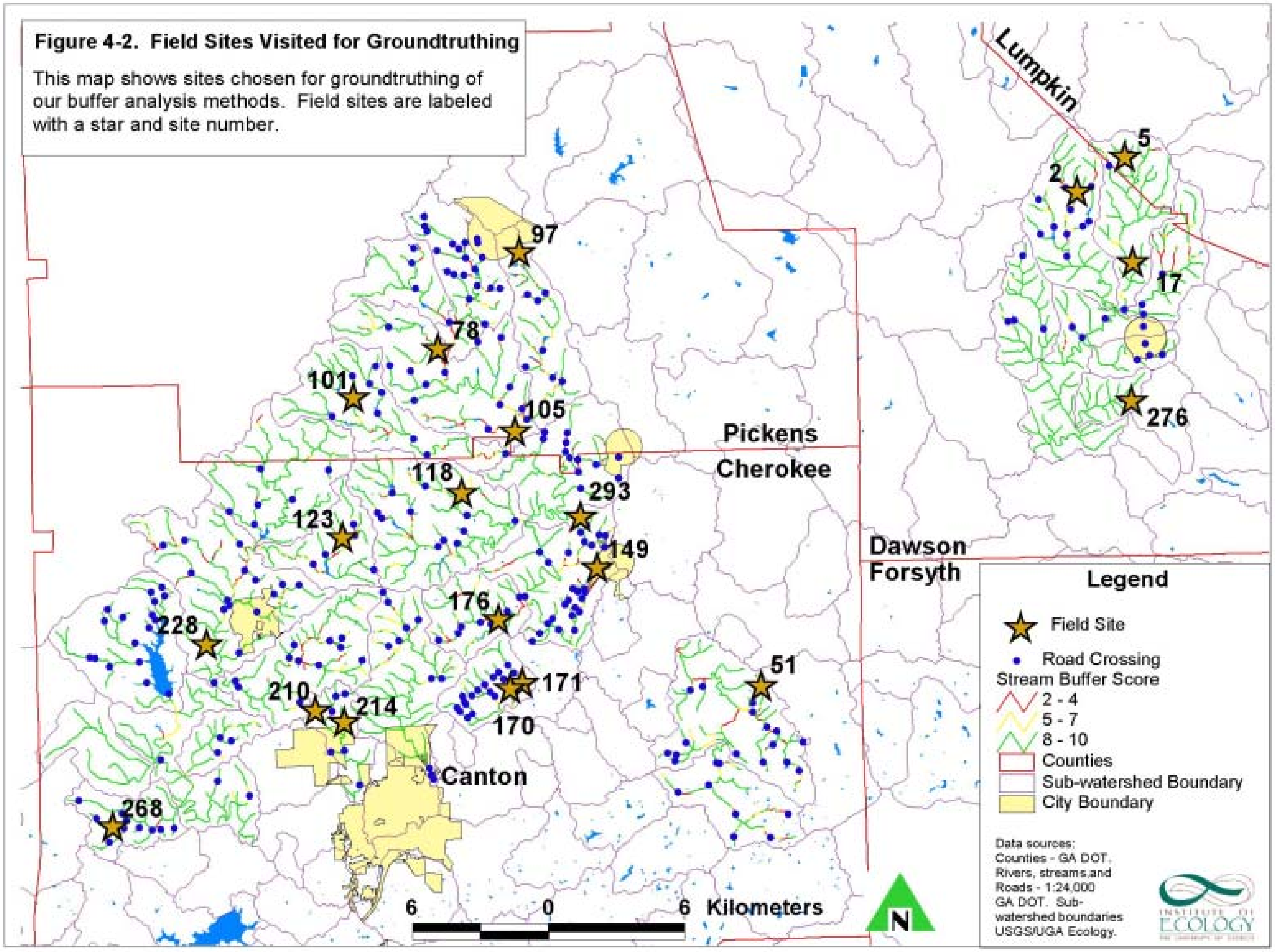


Figure 4-2. Field Sites Visited for Groundtruthing

This map shows sites chosen for groundtruthing of our buffer analysis methods. Field sites are labeled with a star and site number.

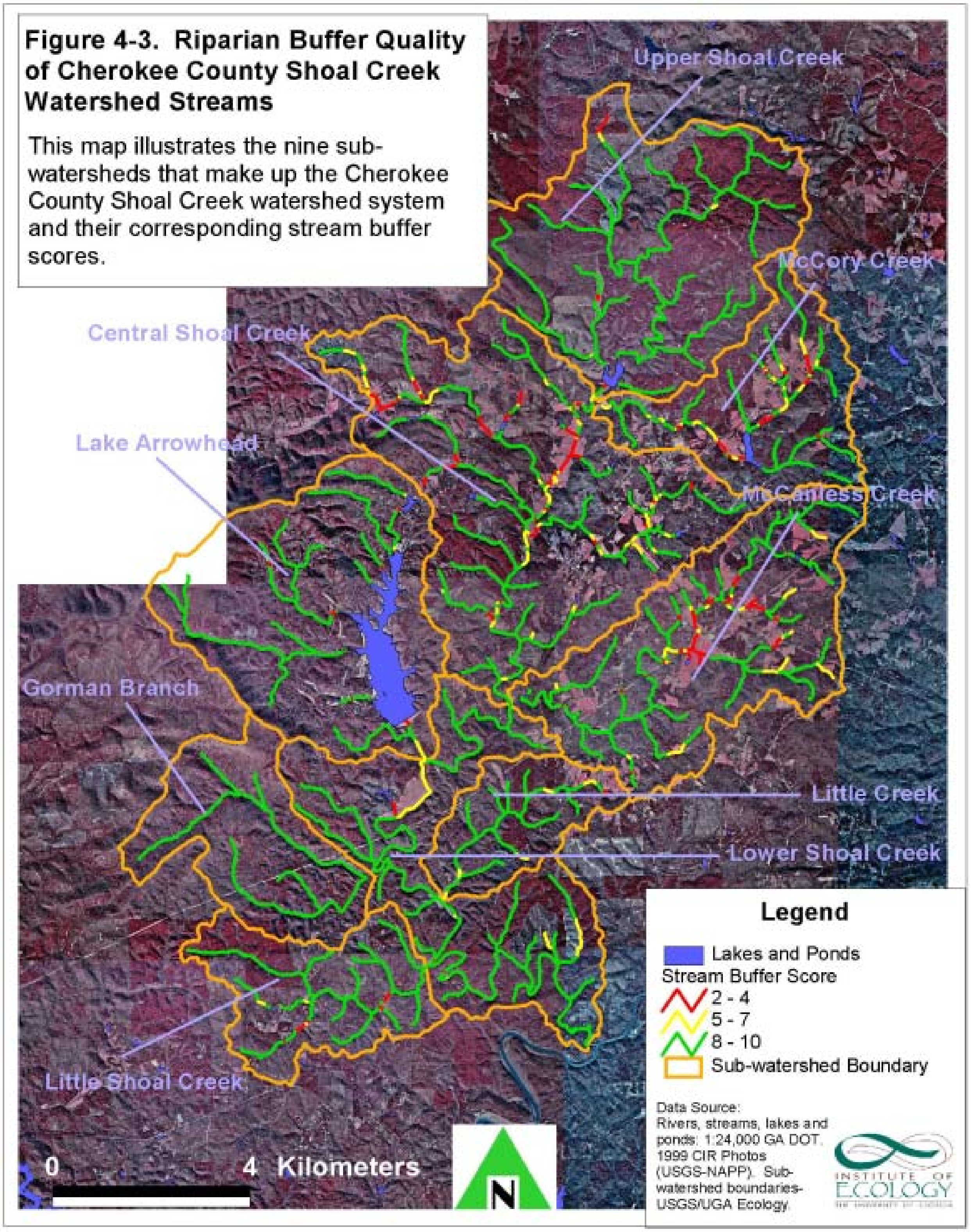


Figure 4-3. Riparian Buffer Quality of Cherokee County Shoal Creek Watershed Streams

This map illustrates the nine sub-watersheds that make up the Cherokee County Shoal Creek watershed system and their corresponding stream buffer scores.

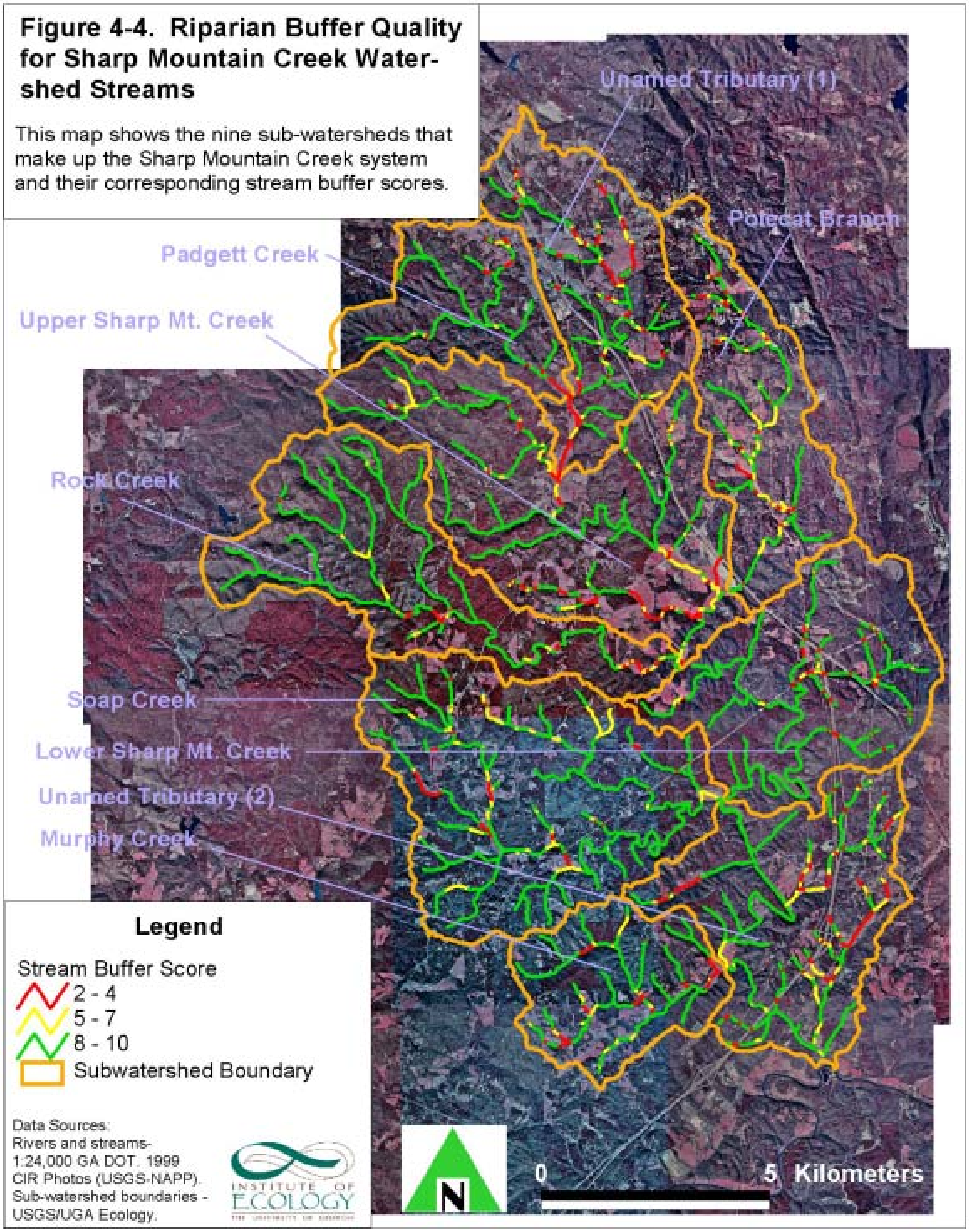
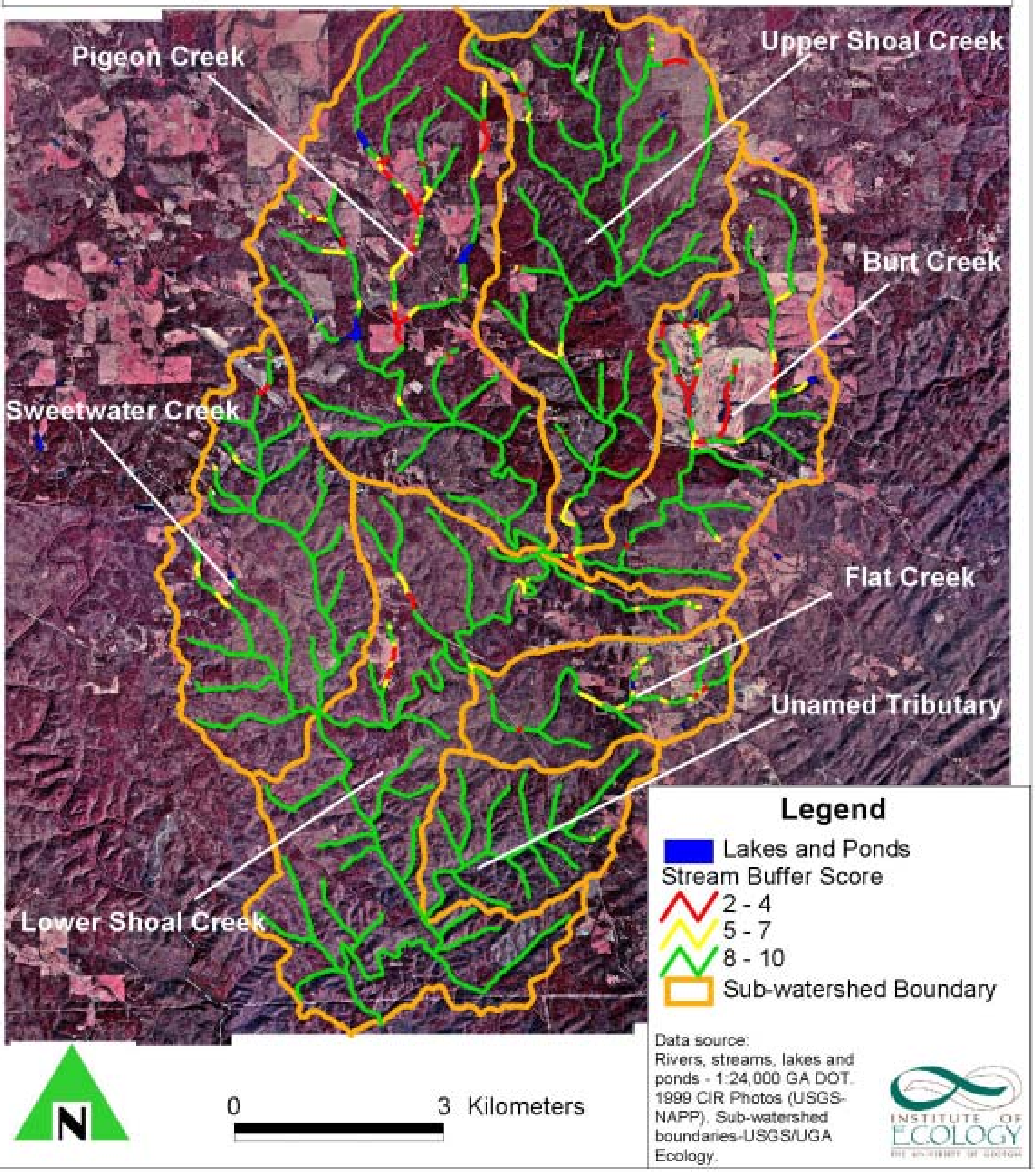


Figure 4-4. Riparian Buffer Quality for Sharp Mountain Creek Watershed Streams

This map shows the nine sub-watersheds that make up the Sharp Mountain Creek system and their corresponding stream buffer scores.

Figure 4-5. Riparian Buffer Quality of Dawson County Shoal Creek Watershed Streams

This map depicts the seven sub-watersheds that make up the Dawson County Shoal Creek system and their corresponding stream buffer scores.



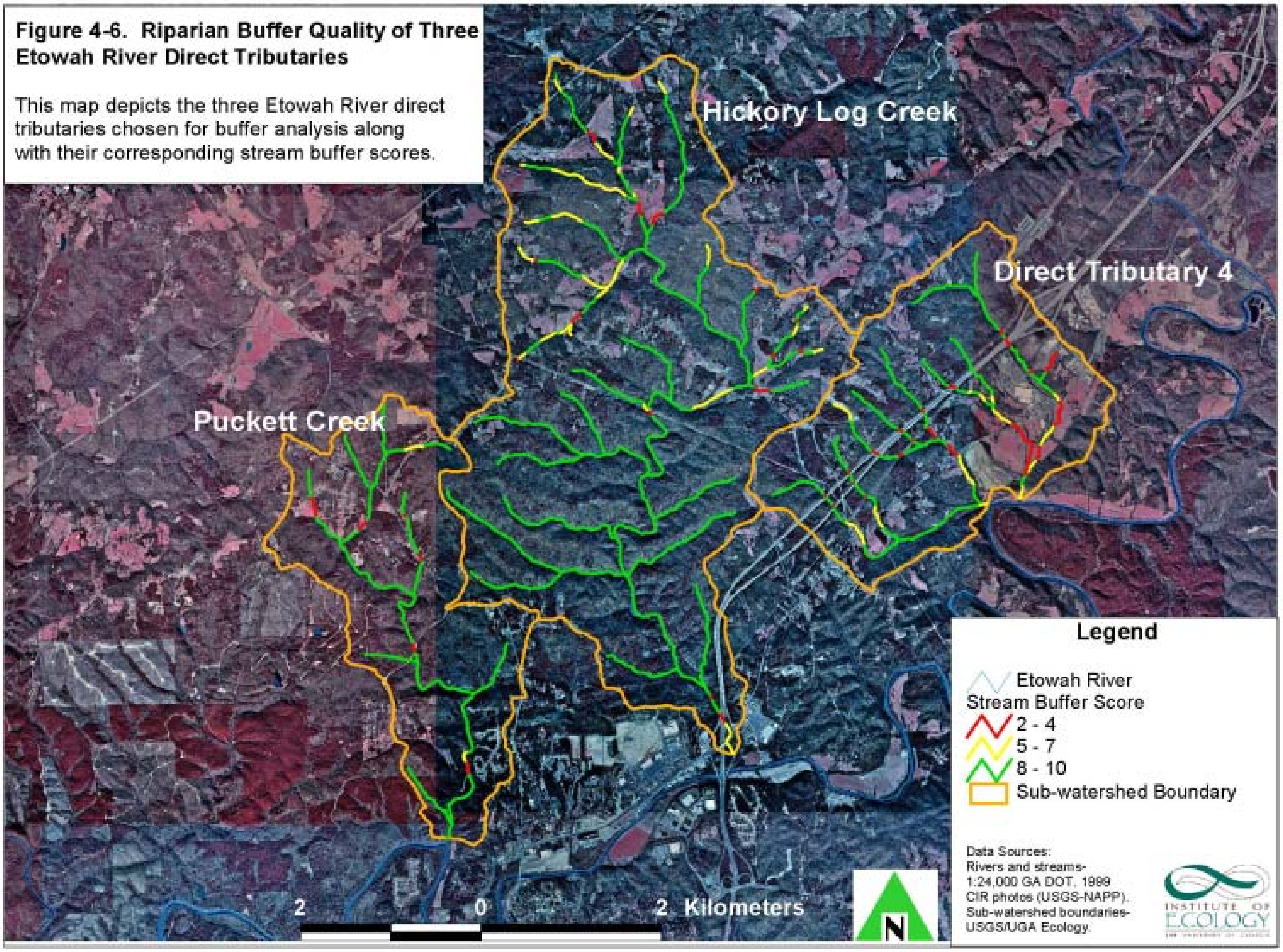


Figure 4-6. Riparian Buffer Quality of Three Etowah River Direct Tributaries

This map depicts the three Etowah River direct tributaries chosen for buffer analysis along with their corresponding stream buffer scores.

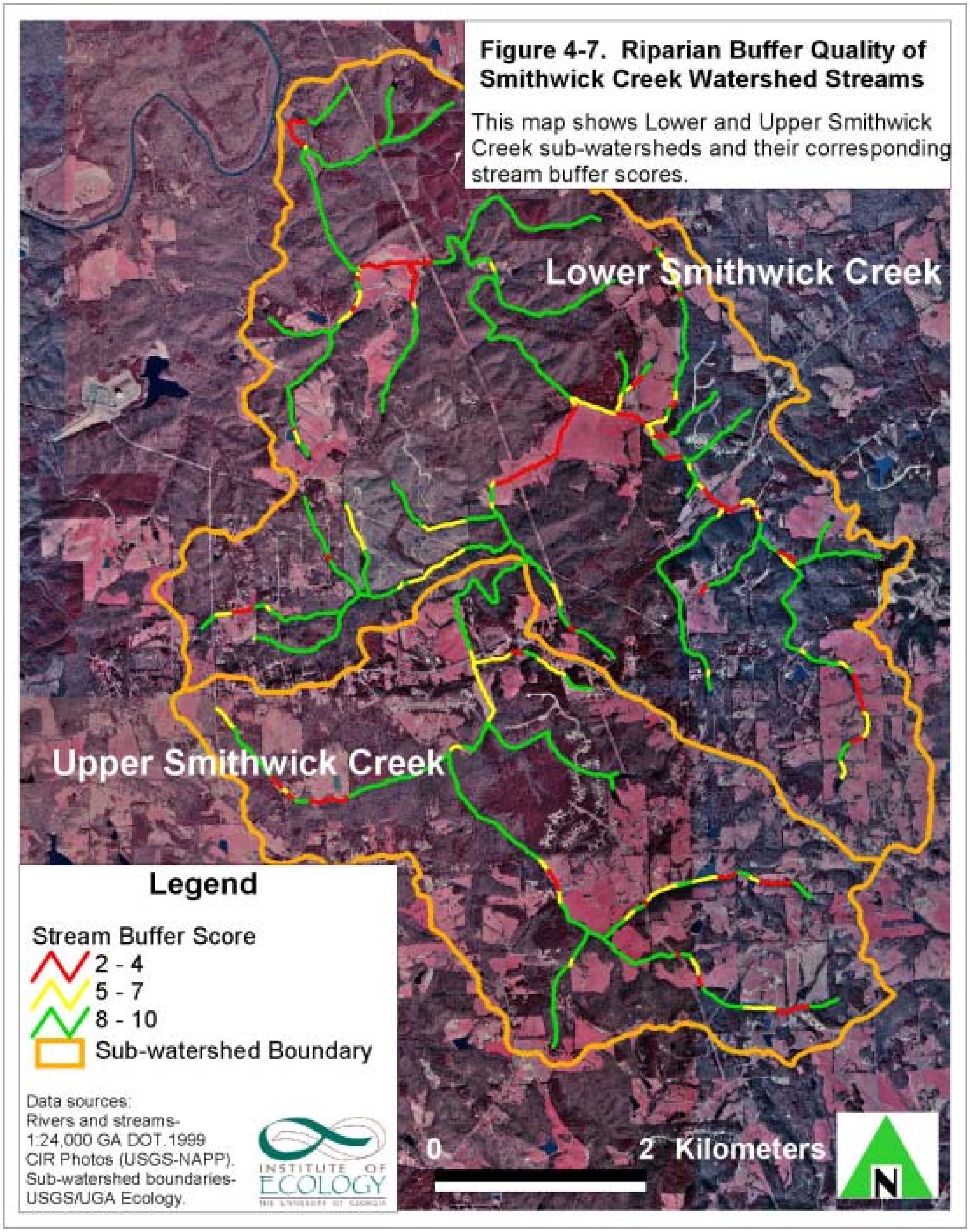


Figure 4-7. Riparian Buffer Quality of Smithwick Creek Watershed Streams
This map shows Lower and Upper Smithwick Creek sub-watersheds and their corresponding stream buffer scores.
Lower Smithwick Creek
Upper Smithwick Creek
Legend
Stream Buffer Score
2 - 4
5 - 7
8 - 10
Sub-watershed Boundary
Data sources:
Rivers and streams-
1:24,000 GA DOT.1999
CIR Photos (USGS-NAPP).
Sub-watershed boundaries-
USGS/UGA Ecology.
INSTITUTE OF ECOLOGY
0
2 Kilometers
N

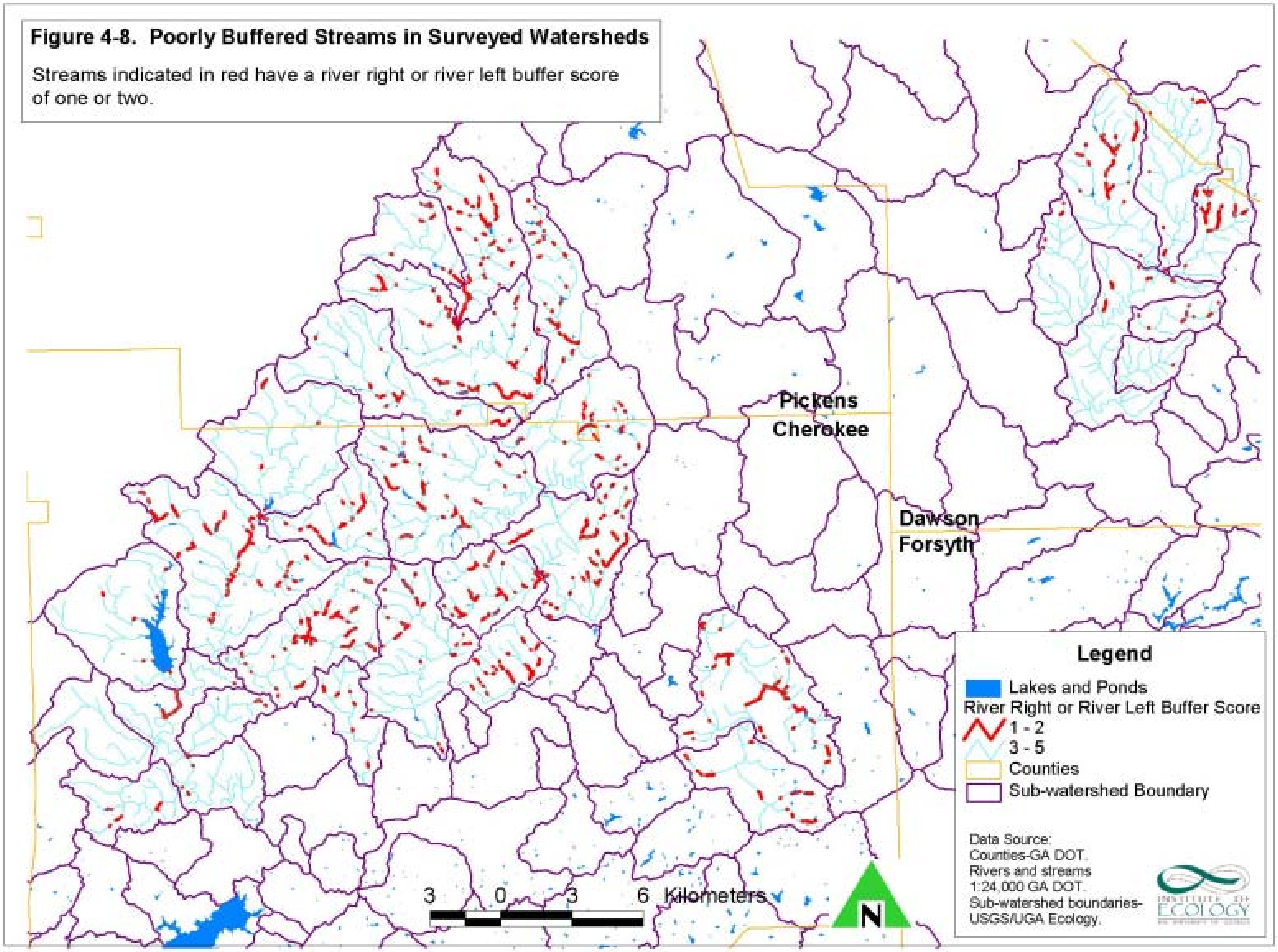
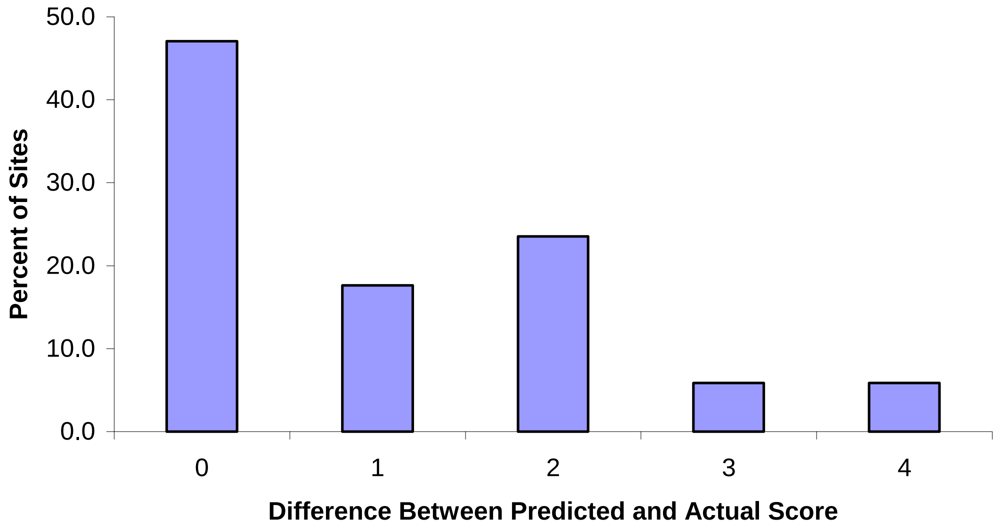


Figure 4-8. Poorly Buffered Streams in Surveyed Watersheds
Streams indicated in red have a river right or river left buffer score of one or two.
Pickens
Cherokee
Dawson
Forsyth
Legend
Lakes and Ponds
River Right or River Left Buffer Score
1 - 2
3 - 5
Counties
Sub-watershed Boundary
Data Source:
Counties-GA DOT.
Rivers and streams 1:24,000 GA DOT.
Sub-watershed boundaries-USGS/UGA Ecology.
3 0 3 6 Kilometers
N

Figure 4-9. Predicted vs. Actual Riparian Buffer Scores: Frequency Distribution of Error.



V. Putting Tools Into Action

This report has identified the major threats to the imperiled aquatic species of the Etowah and discussed tools to address those threats. But knowing what to do is only the first step; the difficult part is putting the tools into action. Currently there are several efforts underway to protect water quality, preserve imperiled species habitat and manage growth. Some are listed below.

The first is the University of Georgia's **Etowah Practicum**. This is an interdisciplinary course taught by Laurie Fowler and other faculty members that involves students from the UGA Institute of Ecology, School of Law, School of Environmental Design and other departments in solving problems related to resource protection and growth management in the Upper Etowah. Local government officials typically identify problems to be addressed in the practicum. For example, past projects included creation of a conservation subdivision ordinance for Cherokee County and development of road crossing recommendations. The Etowah Practicum has been taught since 1997 and will continued to be taught at least one semester per year in coming years. Information is available at *http://outreach.ecology.uga.edu/.*

The second is the **Upper Etowah River Alliance** (UERA). The UERA was formed in 1997 "to provide regional leadership and education for maintaining the natural beauty and quality of the Upper Etowah River Watershed, which meets the needs of property owners, a prosperous economy and the environment." The group conducts stream restoration projects and environmental outreach to raise awareness of threats to the watershed. Because it draws its membership from diverse organizations and backgrounds, the alliance tends to take a conservative approach and is unlikely to be a strong advocate for contentious new growth management policies. Information is available at *http://www.etowahriver.org/.*

The third is **The Nature Conservancy's Etowah Program**. The Nature Conservancy is a partner with the Upper Etowah River Alliance, but also is pursuing broader efforts to protect the biodiversity of the Etowah basin. The organization has already begun implementation of many elements in the draft Site Conservation Plan, discussed in Section I.

Various state and federal agencies have programs that focus on the Etowah, especially Lake Allatoona. **The Army Corps of Engineers** manages the lake, and at the time of this writing is investigating methods of controlling sedimentation in the basin. The **Lake Allatoona Preservation Authority** (LAPA) is an entity created by the Georgia General Assembly in 1999 to protect water quality in the reservoir. Projects managed by LAPA include a source water assessment of the Upper Etowah watershed. The U.S. Fish and Wildlife Service has authority for enforcing the Endangered Species Act, and consults with government projects and private projects that require federal permits in order to minimize impacts on federally listed species in the Etowah and elsewhere. The U.S. Fish and Wildlife also funds research on imperiled species, including this report.

The newest effort is the development of a **Habitat Conservation Plan** (HCP) for the imperiled aquatic species of the Etowah. While it is generally illegal to "take" a federally listed species, Section 10 of the Endangered Species Act allows the federal government to issue an *incidental take permit* if the recipient implements an approved Habitat Conservation Plan. Many HCPs are issued to large private landowners, who agree to manage their properties in ways that protect imperiled species. As discussed in this report, the major threat to imperiled species in the Etowah appears to be threats associated with development. Since local governments have primary authority to manage the pattern and nature of land development activities, it makes sense to develop a Habitat Conservation Plan with local governments (counties and municipalities) as permittees. Once the HCP is completed and approved, participating local governments can issue certificates of inclusion to developers and others who need to obtain government permits for activities that may impact aquatic habitat.

The U.S. Fish and Wildlife has awarded a grant to researchers at the UGA Institute of Ecology and partner organizations to begin developing the HCP. The project is expected to take several years. The first year's objectives are:

- Obtain commitments from counties and municipalities, along with other major stakeholders, to participate in the HCP planning process.
- Form a stakeholder steering committee and a technical advisory committee to guide development of the plan and hold meetings at least quarterly.
- Begin to identify the mechanisms of habitat degradation and the thresholds at which development results in the loss of sensitive aquatic organisms. The first year goal is to describe the relationships between watershed land cover and the distribution of imperiled species.
- Conduct baseline surveys to assess citizen awareness of imperiled species and attitudes toward biodiversity.
- Initiate a public education campaign to raise awareness of the unique aquatic fauna of the Etowah Basin, as well as the value of biodiversity. Year one activities will include creation of curriculum materials, at least one poster, a fact sheet, public service announcements and a web site. At least three public meetings will also be held.

The crux of the plan is that participating jurisdictions will implement ordinances and policies to minimize impacts of development on listed species and other imperiled or sensitive aquatic biota. While this report provides general information on what ordinances and policies are useful for minimizing stressors to imperiled species, many questions remain. The research conducted as part of the HCP will attempt to resolve questions regarding which stressors are most significant and which tools are most effective. The HCP agreement itself will provide local government with a degree of predictability with respect to federal regulations under the Endangered Species Act: once the incidental take permit is issued, most other consultations with the Fish and Wildlife Service can be eliminated, and individual HCPs for private landowners will be unnecessary. At the same time, development will be managed in a way that minimizes impacts to imperiled aquatic species. We believe that the HCP represents the best hope for balancing the economic health of the region with strong protection of the aquatic biota of the Etowah.

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